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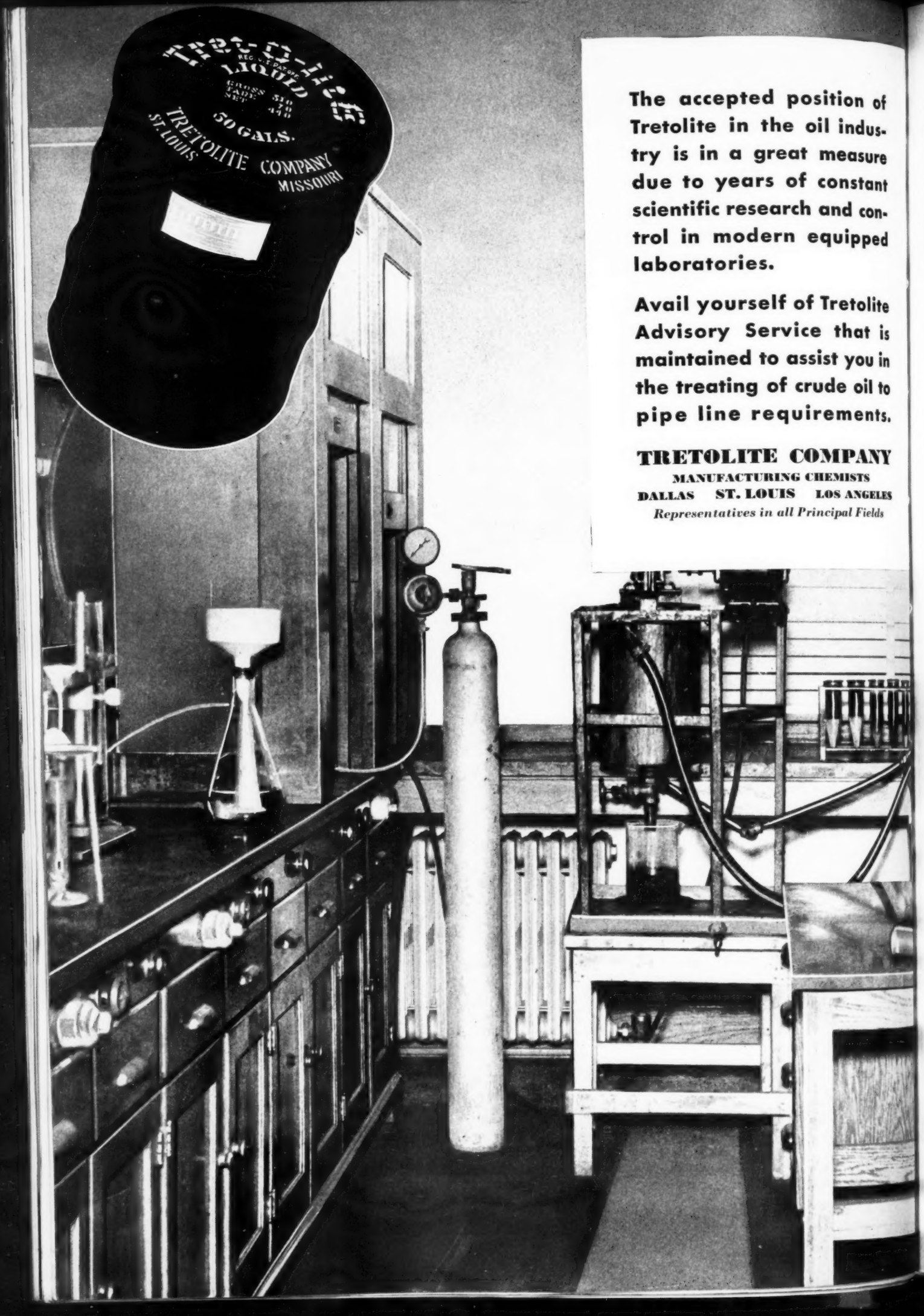

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THE Petroleum Engineer

NOVEMBER 1936 VOLUME VIII NUMBER 2

A MAGAZINE OF METHODS FOR OPERATING MEN

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The Course of Oil

By K. C. SCLATER

A Matter of Technical Ascertainment

As a public official responsible for the regulation of oil production in his state, Ernest O. Thompson, chairman of the Railroad Commission of Texas and also of the Interstate Compact Commission, has acquired a rare understanding of the technical problems involved in efficient oil production.

His enlightened views on this subject are forcibly expressed in the following excerpts taken from his address before the American Petroleum Institute, at its annual meeting in Chicago this month, in which he discusses the accomplishments of the Oil States Compact.

"It (the Oil States Compact) presupposes that regulation is conceded to be desirable; that there is general agreement upon having the best rule or practice prevail, and that the best rule is a matter of technical ascertainment. "

"If the industry does not sincerely and truly and faithfully follow the course of adopting the best technical rule, once it is known and fully demonstrated, then you cannot expect to avoid the heavy hand of complete statutory compulsion by the several states."

"The American people *** are for efficient operation of our oil production to the end that the greatest ultimate recovery may be had***. The oil industry justifiably boasts of a constantly improved product (gasoline) at a constantly lower price. It is taxes that make gasoline appear to be high."

"All will agree that waste should be prevented when the scientific means are known and made available."

"There is no sadder sight than an oil field which has been operated for sudden profits without regard for the incident waste and the ultimate loss to the field and the State in oil that has been negligently left in the sands never to be recovered, or if recovered at a greater cost. Every oil man knows the story. May those economic tragedies soon be a thing of the past! It is to this end the Oil States Compact is dedicated."

Comparing past production practices in Texas with those of the present he says: "In the past years we had horrible examples of wasteful practices. All who experienced the days of Ranger, Burkburnett and Desdamona can bear witness. But we have learned our lesson. Texas is now dedicated to waste prevention. We *are* preventing waste in Texas."

"The East Texas field has produced over one billion barrels of oil in its more than five years of production. During the month of October, fourteen million barrels of oil were produced in that field and the bottom-hole pressure increased one pound during that month. The pressure is 1184.5 pounds today. It was 1201.0 pounds per square inch in July, 1933. Since that time more than 600 million barrels of oil have been produced from the East Texas field. I call that a record in conserving the energy which makes the oil flow. There are 21,600 oil wells in that field; 18,520 of these wells are still flowing. They make their allowable, twenty barrels per day, by flowing about fifteen minutes each day. They are shut in the rest of the time and the slow intrusion of water washes the oil through the sand and keeps the pressure constant or builds it up as happened last month."

"The Compact is not trying to revolutionize the industry. We are simply trying to bring all the oil states to a recognition of the simple ways to prevent waste and thereby save to their people the greatest possible ultimate yield of oil and gas."

"This is an easy way to uniform conservation laws and uniformly good production practices through the interchange of the most progressive thought from one regulatory body in one state to those similarly engaged in other states."

"With regard to the wild drilling campaign now in progress, it is easy to see where we are heading unless some restraint in your own interest is exercised by the producers themselves. Law or regulation cannot remedy this."

"Of course, the oil industry can drill itself to death and drown itself in its own oil if it prefers suicide to prosperity. This cannot properly be stopped by law. It can be averted only by intelligent action of the operators themselves."

Rewarding Progress by Taxation

Important benefits accruing from research and technology in industry are nullified all too often by taxation. A shining example of this is the fact that economies effected by the laboratories of the petroleum industry are more than matched by taxation that raises the price of gasoline.

Comment on this subject in the current issue of *Industrial and Engineering Chemistry*, the official publication of the American Chemical Society, calls attention to the fact that, "in the laboratories of the industry and those concerned with its problems and products, research goes ever forward in an effort to reduce the cost of manufacture, to increase the supply, thereby decreasing the expense of continual exploration, and to improve the quality of the fuel, as well as of lubricating oils. No one knows what prices might be but for these efforts, but how hopeless is this race between research and technology and the monopoly taxation!"

"***Too frequently all that a new process saves in manufacture, as reflected in the lower selling price, disappears entirely before the product in which it is used reaches the ultimate consumer. We wonder what the chemist would need to do to so reduce the price of a dyestuff as to pass on a noticeable reduction to the purchaser of a gown or suit of clothes. Surely it would be a prodigious undertaking, and yet someone does profit. It is not the chemist. It is not the manufacturer of the chemicals. It is rarely the ultimate consumer."

Improvements brought about by research and technology in reducing the price of petroleum products and extending their field of utilization would seem to have made the petroleum industry a vulnerable victim of excessive taxation. Such is the reward of progress.

« « HIGHLIGHTS IN OILDOM » »

Pressure Decline In Rodessa Field

On the Louisiana side of the Rodessa field bottom-hole pressures have declined 153 lb. since July 7, according to data compiled by the Rodessa Engineering Committee working with the Rodessa Operators' Committee. The average bottom-hole pressure now is 2009 pounds.

During the 51-day period from July 7 to August 27 the pressure drop was 152 lb., or 2.99 lb. per day. During the succeeding 31 days the drop was 82 lb., or 2.64 lb. per day; and for the following 30-day period the drop was 71 lb., or 2.37 lb. per day.

●

Fix Spacing Rules for Texas Fields

The Texas Railroad Commission has announced field rules, including spacing regulations, for four Texas oil pools.

For the Eureka field in Harris County, the Nome field in Jefferson and Liberty counties, and the Heyser field in Calhoun County, 20-acre spacing has been approved. Ten-acre spacing was adopted for the Gillock pool in Galveston County.

These orders were issued following hearings at which data on conditions in the individual fields were presented.

The four fields were ordered prorated on a basis involving both acreage and potential.

The gas-oil ratio of the Eureka, Nome, and Gillock pools was set at 2000 cu. ft. of gas per bbl. of oil, while that of the Heyser pool was placed at 2500 cu. ft. of gas per bbl. of oil.

●

Avant Field of Oklahoma to Be Repressured

Repressuring of the Avant field of Oklahoma with gas has been sanctioned by the United States Department of Interior and a comprehensive program is expected to be put into effect in the immediate future. The proposal was made in March by engineers of the Wolverine Oil Company, the Sinclair Prairie Oil Company, and the Phillips Petroleum Company and notification of approval has just been received from Washington, D. C.

The Avant pool comprises 28 quarter sections, or 4480 acres, and the producing wells are owned by the three companies mentioned. It has been stated by representatives of these companies that they hope to be able to drill at least five input wells during 1936, and to conduct an extensive program of drilling gas-input wells in 1937.

The Avant repressuring program will be accompanied by a new royalty agreement with the government. Heretofore the latter has required the payment of one-sixth royalty on production in the Osage reservation for wells making less than 100 bbl. daily. It has consented to ask but one-eighth royalty for a period of 18 months, in order to encourage operators to achieve success in the project.

California Bans Drilling on Ocean Front

California voters have made illegal the drilling of oil wells on the ocean front. This proposition, placed on the ballot at the recent general election, was defeated. If passed it would have permitted operators to make locations on highlands and by means of directional drilling tap the oil sands beneath the ocean.

●

Colombia, S. A., Revises Petroleum Law

By revising Petroleum Law 37, affecting petroleum concessions, the government of Colombia, South America, has taken a long forward stride in encouraging the exploitation of its petroleum resources. A number of the law's provisions have been modified. Operations on private property are facilitated by making easier the clearing of titles. Requirements concerning the submission of geological and geophysical evidence also are made less exacting.

Another provision of the law as revised permits the extension of concessions three years longer than was allowed previously by payment of one peso per hectare for the seventh year, one and one-half pesos for the eighth year, and two pesos for the ninth year. Of importance, too, is the granting of substantial reduction in severance taxes on oil produced provided operations start within 15 years from the date the law became effective.

●

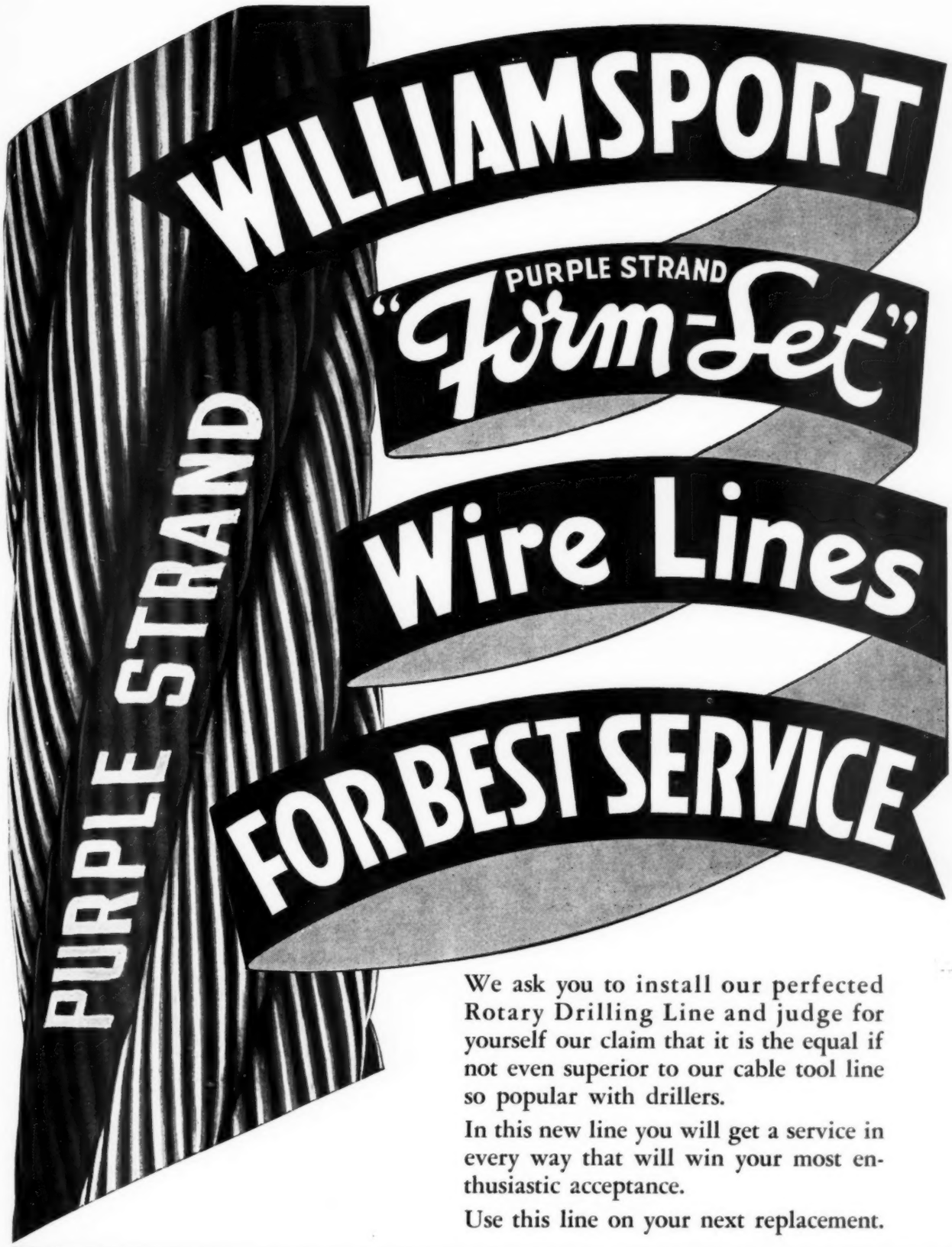
Fitts Spacing Rule Modified

The State Corporation Commission of Oklahoma has issued a formal order approving the application of J. E. Crosbie, Inc., for modification of the 10-acre spacing orders for the Fitts area as they apply to the Upper Simpson, Wilcox, and Hunton lime zones, permitting irregular spacing within units comprising 160 acres of leases. The area involved is the west half of the southeast quarter and the east half of the southwest quarter of 22-2n-7e in Pontotoc County. While the order permits drilling on an irregular spacing plan, each tract will be approximately ten acres in area, and each well must be drilled as nearly as possible, topography considered, to the center of each prescribed tract.

●

Crude Prices Advanced

A five cents per bbl. advance in crude oil prices was announced recently for certain fields in Texas and for Western Kentucky. The advance was on heavy crudes, apparently resulting from strong demand for fuel oils. Texas fields affected were those in the Gulf Coast and South Texas areas, and the Talco field of northeastern Texas.



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Latest Activities In The Oil Fields

ATTENTION recently has been focused on Collin County, Texas, 70 miles north of Dallas, that area having possibilities of a new field as a result of showings in the California Consolidated Oil Company's No. 1 W. L. Fagg. The Woodbine sand was encountered at 1450 ft., and a showing of gas was had. Cores were taken between 2651 ft. and 2771 feet. At 2672 ft. the Paluxy was penetrated and from that point to the bottom of the hole the cores contained 60 ft. of light brown oil sand.

●

Two new pools have been opened in Michigan recently. The latest discovery is that of the Pure Oil Company, whose No. 1 Embrey in Isabella County initially produced 250 bbl. of high-gravity oil from Monroe lime at a depth of 3606 feet. When deepened to 3611 ft. the flow increased. The test is on the Broomfield structure.

The other Michigan discovery was that of the Chartiers Oil and Gas Company with their No. 1 Currie. This strike also was in Isabella County. Drilled to a depth of 3927 ft. in the Dundee lime the hole filled up 2200 ft. with oil in 24 hours, and on the second day made a natural flow of 50 barrels. After being treated with acid it flowed at the rate of 100 bbl. an hour.

●

Recent gas discoveries in Kentucky have resulted in plans for extensive drilling and exploration activities in the area. In McLean County, five miles west of Sacramento, The Cumberland Petroleum Company successfully completed a well in the Barlow sand that produced 10,000,000 cu. ft. of gas daily. Approximately 100 ft. from this well another was drilled to the Jett sand, encountered at 1400 feet. The well gauged 21,000,000 cu. ft. daily, the largest gas well east of the Mississippi River.

●

The Olson Drilling Company and the Watchorn Oil and Gas Company's No. 1 Morrison in Clark County, Kansas, promises to be a pool opener. The Viola lime was encountered at 6467 ft. and on a drill stem test the wildcat flowed 33 bbl. of oil in half an hour. Cores taken to a depth of 6494 ft. showed saturation. Total depth is 6484 feet.

●

Another deep oil field is in prospect for North Louisiana as a result of the United Gas Public Service Company's discovery on the southwestern flank of the old Sligo gas field, Bossier Parish. Drilled to a total depth of 5201 ft. that company's No. 1-F H. L. Skannal flowed initially at a rate of 300 bbl. daily, producing from the Pettitt sand, and the flow was increasing slowly.

●

Murray County, in south-central Oklahoma, has been in the limelight recently, Power Oil Company et al's No. 1 Lancaster Trust Company giving promise of opening a new pool. Cores taken from 2951 ft., the top of the Hunton lime, to the bottom of the hole at 3002 ft. showed oil saturation.

●

According to reports, oil has been discovered by a wildcat well in the Motembo basin of Cuba by the Compania Petrolera Degener De Cuba. In its No. 2 well an oil showing was obtained at 150 ft., but the test was drilled ahead and at the latest report was at a depth of approximately 700 feet. The same company is drilling another test in the area.

●

Drill stem tests taken on the Gulf Oil Corporation's No. 2 Wilkes and Smith test in Brazoria County, Texas, so far have been favorable and indicate the opening of a new pool for that area of the Gulf Coast. After drilling to a depth of 6450 ft., the test was plugged back to 6380 feet. At the latest report a 7-in. liner was being set below 9⅝-in. casing, with another test to follow.

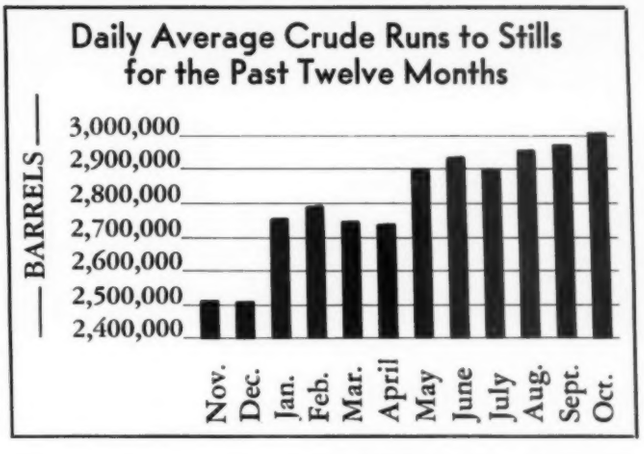
AVERAGE CRUDE PRICES

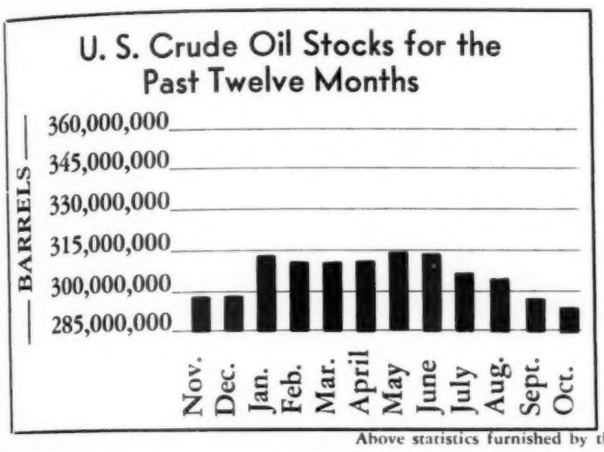
California	
Kettleman Hills	$1.22-1.43
Playa Del Rey	1.10
Coalinga	.70-.90
Signal Hill	1.10
Montana	1.35
Wyoming	1.10
Colorado	1.00-1.10
New Mexico	.75-1.00
Texas	
North Central	.84-1.08
Panhandle	.81-.98
West Texas	.75-.95
Gulf Coast	.85-1.30
Darst Creek	.88-1.22
East Texas	1.15
Kansas	1.10
Oklahoma	1.10
Arkansas	.75-.80
Louisiana	
Gulf Coast	$ .82-1.22
North Louisiana	.86-1.10
Illinois	1.23
Kentucky	1.28
Indiana	1.12
Ohio	
Lima	1.15
Michigan	.70-1.32
Pennsylvania	
Bradford	2.45
Southwest	2.17
Eureka	2.12
Buckeye	1.97
Corning	1.32
West Virginia	1.67
Canada	2.10-2.17

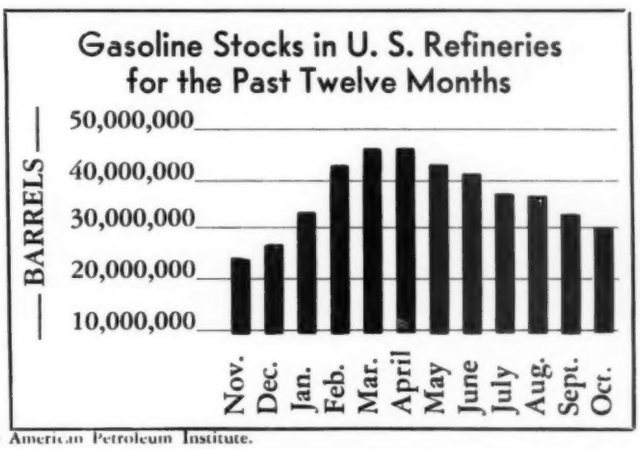
DAILY CRUDE OIL PRODUCTION
Data Supplied by A.P.I.

(Figures in Barrels)

	B. of M. Dept. of Interior Calculations (October)	Week Ended Oct. 31, 1936	Week Ended Oct. 3, 1936	Week Ended Nov. 2, 1935
Oklahoma	559,900	564,750	547,500	492,400
Kansas	155,000	163,400	157,800	149,850
Panhandle Texas		65,950	61,300	55,806
North Texas		65,300	61,100	60,250
West Central Texas		33,800	27,400	21,600
West Texas		170,100	172,350	147,850
East Central Texas		71,100	70,800	44,450
East Texas		439,650	436,550	429,550
Southwest Texas		169,950	84,350	254,600
Coastal Texas		178,100	255,350	
TOTAL TEXAS	1,106,900	1,193,950	1,169,200	1,024,150
North Louisiana		75,450	78,000	33,000
Coastal Louisiana		157,800	157,700	128,100
TOTAL LOUISIANA	189,300	233,250	235,700	161,100
Arkansas	29,600	28,100	28,200	29,850
Eastern	106,300	117,050	114,550	111,100
Michigan	30,000	31,200	29,750	55,650
Wyoming	37,300	40,400	41,250	36,350
Montana	14,200	15,750	15,750	12,900
Colorado	4,300	4,950	4,900	4,250
New Mexico	74,200	83,100	79,100	56,750
TOTAL EAST OF CALIF.	2,307,000	2,475,900	2,423,700	2,134,350
California	535,300	567,600	564,100	664,000
TOTAL U. S.	2,842,300	3,043,500	2,987,800	2,798,350







Above statistics furnished by the American Petroleum Institute.

Summarized Operations in Active Fields for October, 1936

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	192	183	29	75	3500-3700	2	40	Rotary
Duval County	94	83	25	46	1554-2900	2	22	Rotary
Archer County	25	8	7	16	660-1800	1 or 2	40	Rot.-Cab.
Panhandle	54	52	28	137	1700-3900	2	40	Rotary
Refugio County	15	12	2	8	4900-5900	2	38	Rotary
Nueces County	60	52	12	53	3922-5878	2 or 3	21-54	Rotary
San Patricio County	11	8	3	7	3987-6141	2	23-65	Rotary
Talco	21	19	20	30	4230-4361	2	16-24	Rotary
OKLAHOMA								
Oklahoma City	21	20	5	13	6450-6682	3	39	Rotary
Fitts Pool	31	27	14	59	1800-4488	2 or 3	38	Rotary
Osage County	16	16	5	24	380-2850	2	37.5-40	Rot.-Cab.
KANSAS								
McPherson County	9	9	5	16	2900-4300	2	38	Rot.-Cab.
Russell County	27	22	9	32	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	24	22	6	31	3222-4085	2 and 5	42-48	Rot.-Cab.
Reno County	19	14	4	26	3300-4375	2 and 5	42-48	Rot.-Cab.
LOUISIANA-TEXAS								
Rodessa	37	35	15	110	5950-6450	3	39	Rotary
CALIFORNIA								
Kettleman Hills	3	2	3	16	8300-8730	3 or 4	40	Rotary
Midway-Sunset	8	8	11	23	1400-3100	1 and 2	11-30	Rot.-Cab.
Mountain View	5	5	3	11	5200-6000	2	20-40	Rotary
Montebello	5	5	2	7	5000	2	36	Rotary
Kern	5	4	3	7	1000-1200	1	12-15	Rotary

Field Activities by States for October, 1936

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1935 (In Barrels)
	October	September	October	September	October	September	October	September	October	September	
Arkansas	4	6	1	2	10	7	7	6	35	30	11,140,750
California	75	92	59	82	108	94	80	107	244	252	207,899,480
Colorado	3	2	2	1	.....	.....	2	5	29	31	1,565,150
Illinois	.....	9	.....	4	.....	.....	20	27	14	16	4,352,000
Indiana	12	7	8	4	.....	.....	2	4	25	28	762,000
Kansas	136	190	105	146	215	114	54	45	397	325	53,013,450
Kentucky	20	28	20	25	.....	.....	10	6	40	22	4,860,000
Louisiana	91	124	72	104	94	98	44	40	175	173	50,299,950
Michigan	71	81	54	54	66	45	68	70	117	121	15,661,350
Mississippi	.....	.....	.....	.....	.....	.....	3	4	8	8	Gas. Prod
Montana	25	33	20	27	.....	.....	6	7	58	62	4,304,100
New Mexico	51	57	48	54	.....	.....	10	18	108	104	19,195,500
New York	.....	.....	.....	.....	.....	.....	2	3	4	5	3,191,900
Ohio	180	170	122	115	.....	.....	42	52	174	190	4,234,000
Oklahoma	210	276	147	207	271	192	87	79	567	506	181,152,050
Pennsylvania	.....	.....	.....	.....	.....	.....	26	25	151	127	14,478,000
Texas	1095	1192	857	931	1406	1240	566	578	1502	1714	377,747,205
West Virginia	70	37	62	31	.....	.....	53	45	199	168	3,818,400
Wyoming	10	12	7	9	.....	.....	5	6	53	59	13,390,100
Totals	2053	2316	1584	1796	2170	1790	1007	1127	3656	3941	970,995,385

Progress of Major Pipe Line Work

THE East Texas Refining Company, of which Freeman W. Burford, Dallas, is president, has announced plans for the construction of a 6⅝-in. gasoline pipe line to extend from its Longview, Texas, refinery to either Loraine, Louisiana, or Natchez, Mississippi. The right-of-way is being cleared. Should the line terminate at Loraine, a distance of 40 miles, but one pumping station will be erected and the capacity of the line will be 15,000 bbl. daily. In event the line is laid to Natchez, a distance of 210 miles, an additional station will be added and the line's capacity will be increased to 20,000 bbl. daily.

The East Texas Refining Company's refinery at Longview has a capacity of 6000 bbl. of gasoline daily, leaving 9000 to 14,000 bbl. daily to be supplied by East Texas independent refiners to meet the pipe line's capacity.

Decision on whether to terminate the line at Loraine or Natchez is dependent upon the verdict of the Louisiana and Arkansas Railway Company and the Louisiana Public Service Commission with respect to an application for a rate of 6 9/10 cents per cwt. on gasoline in 100 car lots from Loraine to Fillston, on the Gulf Coast. If the rate is not granted it is expected that the line will be extended to Natchez.

The East Texas Refining Company has acquired a tract at Fillston upon which to erect storage and terminal facilities. Loading facilities for both barges and tank cars will be provided.

●

The Shell Pipe Line Company has started laying a 10-in. line from Wink to McCamey, Texas, a distance of 75 miles, replacing two 6-in. lines now in use. The new line is expected to be completed early in January. Using the existing four pumping stations, the capacity of the line will be increased from 35,000 to 50,000 bbl. daily.

●

The C. and S. Pipe Line Company of San Antonio, Texas, owned by La Jita Corporation, headed by John F. Camp, has announced plans for the construction of a 45-mile pipe line from the Bentonville-King district of Jim Wells and Nueces counties to a deep-water terminal at Corpus Christi. It will be a 6-in. welded line and will have a capacity of 10,000 bbl. of crude oil daily. A pumping station will be erected in the Agua Dulce field and a booster station approximately midway to the line's terminus.

●

The Illinois Pipe Line Company has completed its 40-mile line from Lusk to Fort Laramie, Wyoming, where it connects with the Stanolind Pipe Line Company's carrier extending from Clayton, Wyoming, to Freeman, Missouri.

Capacity of the line is 7500 bbl. daily. Approximately 2500 bbl. will be delivered by the line to railhead and trucking depot at Lusk, Wyoming, and 5000 bbl. will continue through the line to the two 55,000-bbl. storage tanks at Fort Laramie, from which it will be boosted into the Stanolind line and mixed with crude from the Clayton tank farm in Converse County, Wyoming.

The White Deer Pipe Line Construction Company of Oklahoma City, Oklahoma, laid the line, 42 days being required. The line was constructed of 6-in. seamless pipe, welded at the joints.

●

The Cabot Gas Corporation will be permitted to lay a 92-mile natural gas line from northern Pennsylvania to Rochester, New York. The New York Central and Erie railroads had sought an injunction to prevent the company from laying a line under 15 railroad rights-of-way between Pennsylvania and Greece, New York, contending that the line beneath the tracks would constitute a hazard. Supreme Court Justice Clyde W. Knapp denied the motion, thus clearing the way for the construction of the line.

●

The American Liberty Pipe Line Company of Dallas, Texas, will lay a 6-in. line from the Sulphur Bluff, Texas, field to the Talco field, a distance of 16 miles, officials of the company have announced. In addition approximately five miles of gathering line will be laid in the Sulphur Bluff field. A 55,000-bbl. tank is being erected at Talco to receive the oil. From there it likely will be moved by tank car, although plans are not yet definite in that respect.

●

A survey is being made by Benedum and Trees Oil Company for a 20-mile oil line from its discovery well in Nevada County, Arkansas, to Camden, Arkansas.

●

A contract for the laying of 15½ miles of 4½-in O.D. oil line has been let to J. H. Gates of Denver, Colorado, by the William E. Hughes Estate, the line to run from Abandoned Peak, Colorado, to Chama, New Mexico. It will be oxy-acetylene welded by the Lindeweld method. Construction work already is under way.

●

The Lucey Petroleum Company of Dallas, Texas, has awarded a contract to Dewey T. Ross, Inc., for the laying of a 6-in. oil line from the Talco field to Mount Pleasant, Texas, a distance of 20 miles. Work started November 1st. The line is being oxy-acetylene welded by the Lindeweld method.

●

H. C. Price, Inc., Bartlesville, Oklahoma, announces having received the following contracts for the electric welding of pipe lines:

From Hope Natural Gas Company, 90 miles of 14-in. in West Virginia, from Clendenin to Hastings. Ligon and Ligon of Baltimore, Maryland are the general contractors. The entire 90 miles is being laid by the so-called "stove pipe" method.

From I. C. Little, general contractor, 94 miles of 14-in. being laid for the Godfrey L. Cabot Company between Rochester and Wellsville, New York.

From Kelly Dempsey Company, general contractors, 110 miles of 10-in. being laid for the Gulf Refining Company in Missouri and Indiana.

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MASON-NEILAN REGULATOR COMPANY, 1193 ADAMS STREET, BOSTON, MASS., U. S. A.

The Month's Activities In Refining

Percent Refinery Capacity Operated

Western Division, 72.7 Percent **Central Division, 76.8 Percent** **Eastern Division, 82.1 Percent**

A NATURAL gasoline plant having a capacity to manufacture 30,000 gal. per day will be constructed in the Rodessa field by the Cass-Liberty Gasoline Company, work to commence within 60 days, it has been announced. Dudley S. Golding, of Dallas, Texas, will head the organization. Associated with him will be Paul M. Raigorodsky, of Tulsa, as vice-president and general manager; C. Maurice Johnson as treasurer; and these officials, together with Clint W. Murchison and Toddie Lee Wynne of Dallas will form the board of directors. The plant site will be approximately nine miles southwest of the town of Rodessa on property of the American Liberty Oil Company.

Construction work will be in charge of the Petroleum Engineering, Inc., of Tulsa, of which Raigorodsky is head.

●

The Corpus Christi Refining Corporation has placed in operation a 5000-bbl. combination skimming and cracking unit at its Corpus Christi, Texas, plant. The unit was designed and constructed by the Wyatt Metal and Boiler Works, Dallas. Gasoline, naphthas, furnace oils, and fuel oil are being manufactured.

●

Dixie Refining Corporation, a new concern, has announced plans for the erection of a 4000-bbl. skimming and cracking plant on a site near Trenton, Michigan. The property adjoins a marine terminal on the Detroit River, which has been leased by the company. It is stated that the refinery will operate on Mid-Continent crude.

●

The International Bitumen Company has placed in operation a 700-bbl. refinery at Bitumont, Alberta, Canada. Diesel fuel is the principal product. A separation plant supplies 50 bbl. of crude per hour from the tar sands.

●

R. I. Wishnick of New York City, the Continental Oil Company, and the Shamrock Oil and Gas Company have let a contract for the construction of a carbon black plant in Moore County, Texas. It will have a daily capacity of 70,000,000 cu. ft. of gas.

The Shamrock Oil and Gas Company also plans to erect a 2000-bbl. cracking plant in the area.

●

The Pure Oil Company is installing a combination cracking and topping unit at its Smith's Bluff refinery, ten miles south of Beaumont, Texas. The unit is expected to be completed by February and will increase the capacity of the refinery by approximately 10,000 bbl. daily.

●

The new Sligo gasoline plant of the Arkansas Fuel Oil Company in the Sligo gas field of Bossier Parish, Louisiana, has been placed in operation. Its capacity is 15,000,000 cu. ft. of gas daily.

●

A terminal improvement project costing $175,000 has been started by Shell Petroleum Corporation at its Deer Park, Harris County, Texas, refinery on the Houston Ship Channel. The development comprises construction of additional docks and the lengthening of the slip by 600 feet. Present length of the slip is 1900 ft., accommodating three tankers. Its depth is 32 ft. and it is 250 ft. wide at the bottom.

Cost of the wharf will be approximately $68,000 exclusive of piping, while the expenditure for the dredging will total $50,000. The dredging contract has been let to Jancke Service Company of New Orleans, Louisiana, who in turn have sublet it to Capt. S. C. Olhausen. Five months will be required to complete the project.

●

Permission to construct a wharf on their property on the Houston Ship Channel has been asked from the War Department and the Houston Port Commission by the Eastern States Petroleum Company, Inc. Plans as to size and type of docks have not yet been announced, pending approval by the proper authorities.

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks
Week Ended October 31, 1936
A.P.I. Figures

(Figures in Barrels of 42 Gallons Each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbl.	Gas and Fuel Oil Stocks Thousands of Bbl.
East Coast	100.0	534,000	87.3	14,938	13,029
Appalachian	94.8	90,000	61.6	2,201	665
Ind., Ill., Ky.	96.2	445,000	97.4	8,469	6,404
Okla., Kans., Mo.	84.8	264,000	68.8	5,607	3,512
Inland, Texas	48.5	115,000	71.9	1,429	1,862
Texas Gulf	97.0	623,000	87.7	6,896	8,451
La. Gulf	96.4	121,000	74.2	1,537	2,344
No. La.-Ark.	90.0	56,000	77.8	232	423
Rocky Mt.	61.9	49,000	81.7	773	703
California	92.6	502,000	63.6	12,133	73,290
Reported	89.9	2,799,000	78.8	54,215	110,683
Est'd Unreported	.....	241,000	.....	3,767	3,624
*EST'D TOTAL U.S. Oct. 31, '36	.....	3,040,000	.....	57,982	114,307
*EST'D TOTAL U.S. Oct. 24, '36	.....	2,990,000	.....	57,864	114,206
U. S. B. of M. *Oct. 31, '35	.....	**2,746,000	.....	49,798	109,952

**October, 1935, daily average.
*Estimated Bureau of Mines basis.

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Horizontal Two-Stage Uniflow Steam Engine Driven, Ammonia Compressor, Extended Type
Horizontal Two-Stage Ammonia Compressor with Double Seal Stuffing Box and Capacity Control, Motor Driven
Two Horizontal Two-Stage Carbondale Ammonia Compressors with Capacity Control
Horizontal, Two-Stage, Steam Driven Ammonia Compressor, Opposed Type
Horizontal Two-Stage Ammonia Compressors with Motor Drive

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AR-3646

Rigging-up the relief well 836 ft. distant from well on fire

By

K. C. SCLATER

A 7000-ft Relief Well

COOL calculation has replaced guess work, or the gamble if you like, in overcoming one of the most destructive and terrifying hazards of oilfield development; namely, subduing a well that has blown out, cratered, and then caught fire. Cratering usually is the result of high-pressure gas having penetrated sands and shales at the surface and is one of the most difficult situations to control, particularly when the gas has ignited at the surface. Ingenuity, perseverance, and skill of a high order are essential to cope with and bring under control a burning crater.

Extinguishing an oil and gas well on fire by drilling a relief well is an excellent example of the application of technical skill to a highly practical end. The most recent example of the application of such skill is that of extinguishing the fire and killing the burning cratered well, Brooks No. 1 of the Republic Production Company near Silsbee, Texas. It is the fourth and also the deepest burning cratered well that has been successfully killed by this method.

This well blew out on August 5, 1936. A drill-stem testing tool had been run into the hole, and it was while pulling the drill pipe on coming out of the hole with the drill-stem testing tool that the well blew out. A few hours after blowing out the well cratered. About two days later, on August 7, the well caught fire. The crater gradually increased in size and at the time the fire was extinguished on October 3, was approximately 500 ft. in diameter and 30 ft. deep.

Various attempts were made to extinguish the blaze at the surface, but these were of no avail. It was then that the Republic Production Company called upon Eastman Oil Well Survey Company to direct the drilling of a directional relief well. According to a report of the latter company location was made for No. 2 Brooks 836 ft. north 70 deg. 17 min. west of the cratered well. This is the greatest distance that a relief well has been located from the well to be killed. Among the important factors that governed the location of the relief well were the depth of the well, the drilling characteristics of the formations, and the extent of the cratering.

The status of the cratered well at the time it blew out was as follows:

Total depth	6982 ft.
Top of sand found at	6957 ft.
10¾-in. O.D. casing set at	1027 ft.
7-in. O.D. casing set at	6948 ft.

Republic Production Company's Brooks No. 1, Silsbee, Texas. Well blew out, cratered, and then caught fire. It burned for approximately 56 days before being extinguished

A view of the crater after the fire had been extinguished, at which time it measured 500 ft. wide and 30 ft. deep

●

Controlling from the surface the direction of a rotary bit drilling almost a mile and a half underground results in subduing a burning cratered well at Silsbee, Texas

●

Hits Its Mark » » »

A new derrick and drilling rig were set up without delay and the hole spudded in and drilled to 1509 ft., at which point 10¾-in. O.D. casing was set and cemented with 1200 sacks of cement August 21, 1936. Three days were allowed to let the cement set, during which time rigging-up was completed for controlled directional drilling. On August 24, 1936, the plug was drilled and the hole carried to 2096 feet. At this point, an Eastman multiple-shot survey was made. The hole was then drilled to 2190 feet. At this point, the Eastman Oil Well Survey crew, headed by Frank Kellogg, began the skillful operation of deflecting the hole toward the burning crater.

In deflecting the hole of the relief well and maintaining the proper direction and angle desired to hit the hole of the crated well at the depth from which it blew out, a total of ten deflecting tool runs was made. These consisted of nine whipstocks and one Eastman Brewster tool. Eight of the ten deflecting tools were used by the time the hole had reached a depth of 3200 ft., as can be seen from the plat of the horizontal projection. From this depth on, the desired direction and angle were maintained by proper drilling operations; that is, by maintaining the proper weight on the bit, the proper rotary speed, and the proper pump pressure. The last two whipstocks were set farther down the hole mainly to alter the direction and carry the hole directly to its objective. Left turns were desired to overcome the strong right-turn tendency of the formations that had been present up to this time.

The ten deflecting tools were set at the following depths:

2190 ft. whipstock
2251 ft. Brewster tool
2307 ft. whipstock
2367 ft. whipstock
2555 ft. whipstock
2675 ft. whipstock
3100 ft. whipstock
3226 ft. whipstock
5736 ft. whipstock
5858 ft. whipstock

In each setting of a deflecting tool

Looking down into the crater

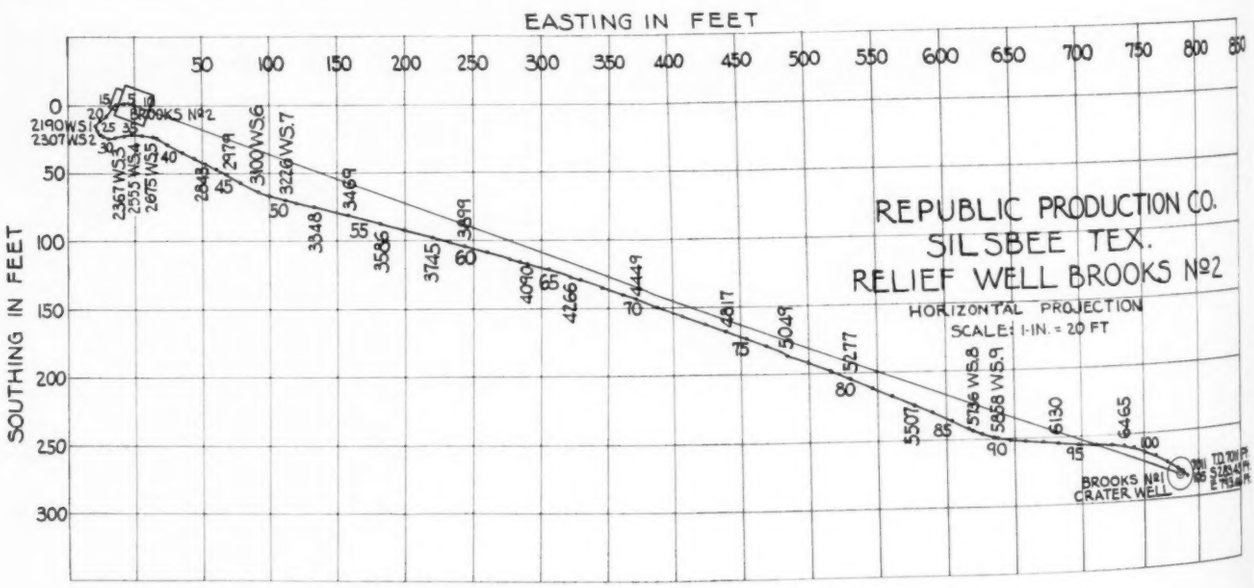
A striking view of the burning well

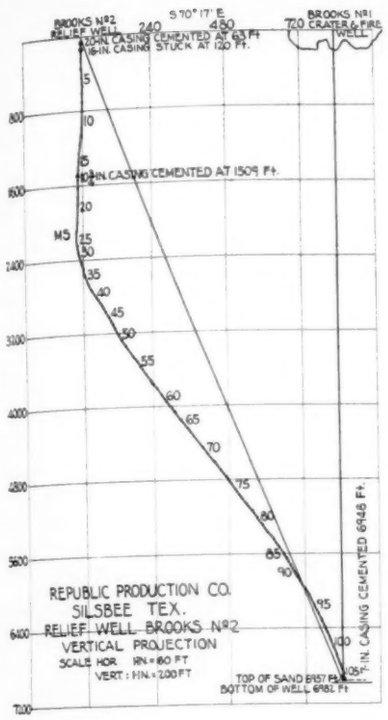
maximum results were obtained, but until the hole had reached a depth of 3000 ft. the lack of bodies of shale and the presence of considerable bodies of sand caused the angle to fall after each case. At a depth of 3300 ft. and after eight deflecting tool runs had been made, the hole had an angle of 12 degrees. A threble of 6-in. drill pipe, with a reamer above and below it, was placed on the bottom of the 4-in. drill pipe. By carrying the proper weight on the bit, running with proper rotary speed, and governing the speed of the slush pump, suitable to the conditions of the formations being drilled, the hole was carried to a depth of 5700 ft. before another deflecting tool run was made. In this manner, the proper angle was maintained, while the direction became slightly off due to the strong right-turn tendency of the formations. By setting two more whipstocks at the depths mentioned above, the direction of the hole was turned to the left and the hole drilled to its objective. On September 21, 1936, a total depth of 7027 ft. had been reached and 7-in. casing was set and cemented at this depth on September 22.

Close attention was paid to maintaining drilling mud in proper conditions throughout the drilling of Brooks No. 2. A mud weighing from 9½ to 10 lb. with a viscosity of 30 sec. was maintained. Before coming out of the hole at any time, from 30 to 60 minutes were spent circulating. In this manner, the hole was at all times in good condition and no trouble whatsoever was experienced in the running of 7-in. casing to a depth of 7026 feet.

Three days after setting and cementing the 7-in. casing at 7026 ft., the cement plugs were drilled and it was found that the cement did not hold. The casing was recemented and allowed to set for another three days.

On October 1, 1936, the plugs were drilled in the 7-in. casing and two cores were taken of the formation, thus carrying the well to a total depth of 7046 feet. At this point, the blowout preventer was closed around the drill pipe and pressure put on the sand at the bottom of the hole. Pumping of





water into the formation was begun at seven o'clock on the morning of October 2, 1936, and at 1:10 a. m. October 3, after 18 hr. of pumping, the fire went out.

In all, approximately 58 days had elapsed from the time the well blew out until it was finally killed.

A summary of the controlled directional drilling operations on the relief well are given in the accompanying table.

The two accompanying plats, one showing a horizontal projection, the other a vertical projection of the relief well, present in graphic form the course of the hole.

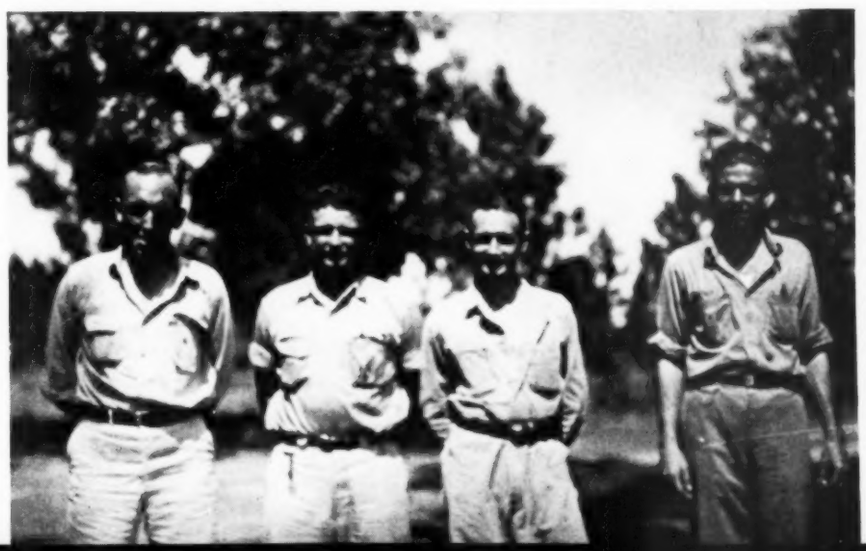
Only the deflecting operations carried out in the relief well are presented here; this phase of the work it was the purpose of this article to present; however, it should be mentioned in passing that many obstacles were overcome that are not recounted here. The successful deflection of the relief well to within a few feet of its objective at this great depth (approximately 7000 ft.) is a tribute to modern engineering science and mechanical skill. It emphasizes the strides that are being made in the development of this art.

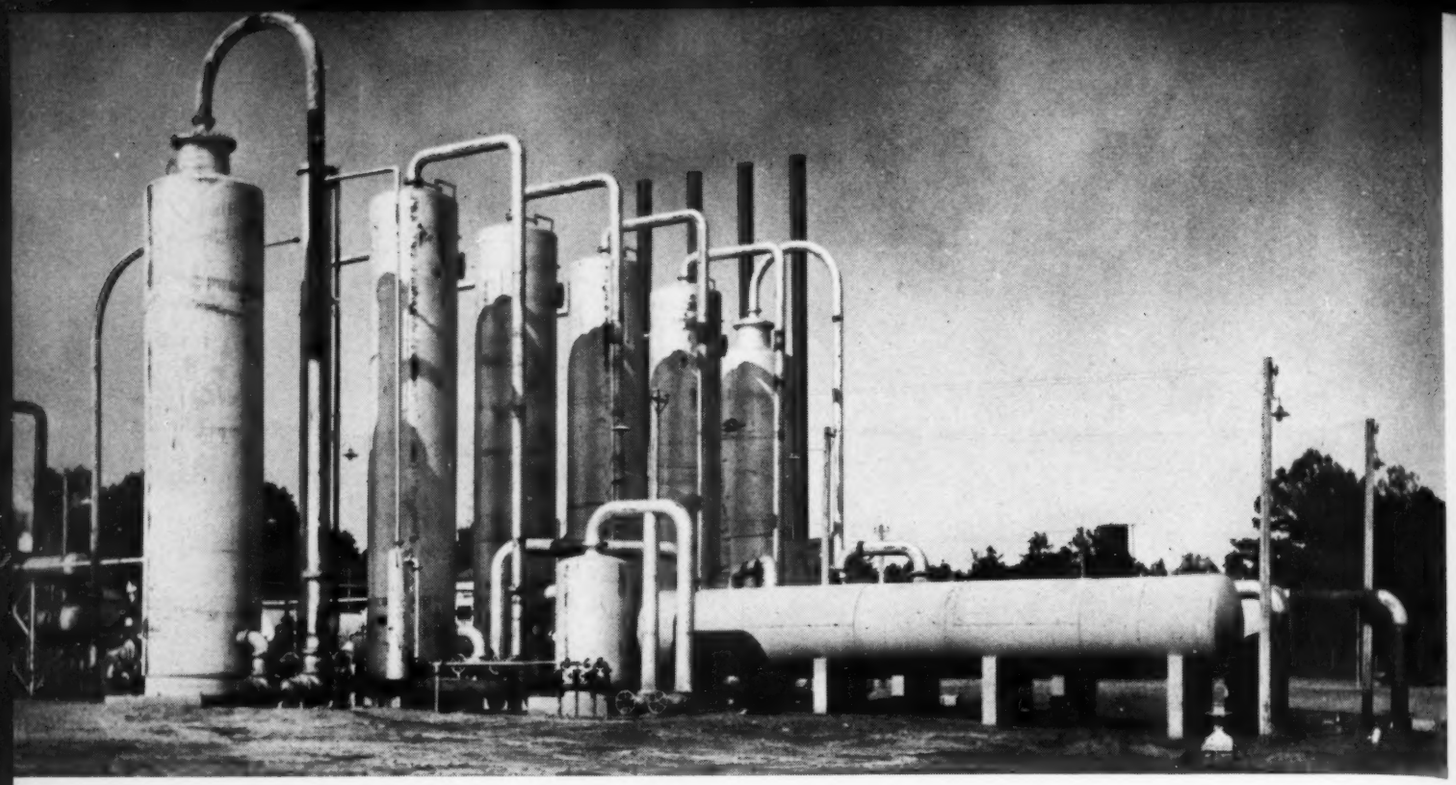
Right—The directional drilling crew. From left to right: Frank Kellogg (in charge), Ralph Walker, Wm. G. James, Gene Brice

DATA ON CONTROLLED DIRECTIONAL DRILLING OPERATIONS ON RELIEF WELL FROM 2096 FT. TO 7024 FT.

Total hole drilled	4928 ft. (from 2096 ft. to 7024 ft.)
Total time	28 days
Average depth per day	176 ft.
Average depth per hr.	7.3 ft.
Total round trips	71
Total time required	186.5 hr.
Average time per trip	2.62 hr.
Total round trips whipstocking	10 (includes Brewster tool)
Total time	46.5 hr. (including drilling)
Average time per whipstock	4 hr. 40 min.
Total time rigging up whipstock	10 hr.
Average time per whipstock	1 hr.
Total single-shot runs	60
Average time per run	34.5
Total single shots	81 (Double single-shot barrel used on some)
Average time per single shot	26 min.
Total trips reaming (Pilot bit following whipstock)	9
Total time required	29.5 hr. (includes reaming and circulating)
Average time per run	3 hr.
Time spent circulating other than after reaming of pilot bit	45 hr.

Below—From left to right: Ralph Walker, Frank Kellogg, Gene Brice. Members of the directional drilling crew posing beside their elaborately equipped trailer, which has all the comforts of a modern hotel





Absorbers and inlet scrubbers—the six absorbers are designed for a maximum pressure of 60 lb. and a maximum temperature of 150 deg. fahrenheit

New Absorption-Type Plant Increases Rodessa's Production of Natural Gasoline

Construction and operating features of Coltexo Corporation's 60,000,000 cu. ft. installation

By
FRANK H. LOVE

NATURAL gasoline production in the Rodessa area of Louisiana and Texas was given a marked stimulus when the Coltexo Corporation placed in operation recently one of the largest plants from the standpoint of capacity yet completed in the field. The rated capacity of the installation is 60,000,000 cu. ft. of gas daily, manufacturing 38,000 gal. of finished product. The plant, of the absorption type, is equipped to produce gasoline in grades varying from 55 lb. down to 14 lb.; at the present time, however, the output is being confined to a 26-55 lb. product. Connected to approximately 50 wells, gas is transported to the plant through a system of gathering lines ranging in size from 8 in. in the field up to 20 in. at the intake. All gas is metered in the field and is brought to the plant under its own pressure, being received at 40-lb. pressure; the residue is discharged at 35 pounds.

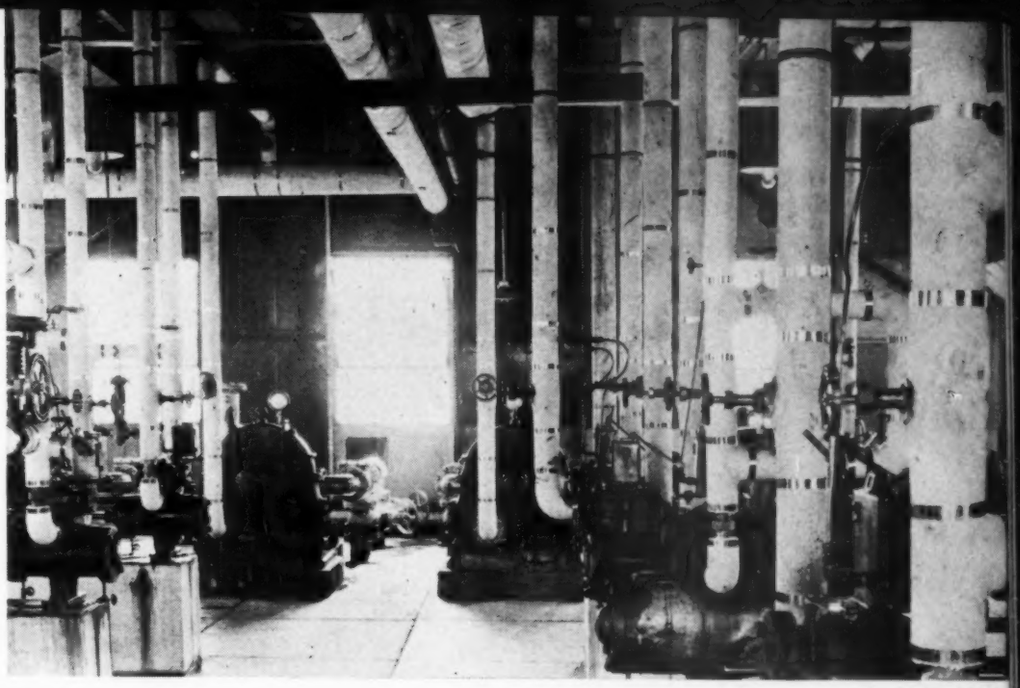
Arriving at the plant the gas is cleaned by two 6-ft. by 40-ft. horizontal inlet scrubbers, then passed through a system of 12-in. headers into the absorbers. The latter number six, four being 6 ft. in diameter by 36 ft. in height, and two 7 ft. in diameter by 35 feet. This equipment is designed for a maximum pressure of 60 lb. and a maximum temperature of 150 deg. fahrenheit. The four 6-ft. by 36-ft. absorbers are equipped with mist extractors in the tops of the units to prevent the absorption oil from leaving with the gas in the form of a spray. Each absorber is provided with a separate oil and gas meter for determining the volume of residue gas leaving the absorbers, and for metering the mineral seal oil.

In connection with the absorption equipment is a reabsorber, employed to extract gasoline from the vapors that leave the accumulator tank. This unit also has separate meters for measuring the vapors and oil entering.

Upon leaving the absorbers the gas is led through a 10-in. line to enter a common 12-in. header, then into the outlet scrubbers. A portion of the residue gas is returned to producing leases, the remainder being burned, thus completing the gas cycle.

The mineral seal oil, with which the gasoline vapors are entrained, begins its cycle when picked up from the fat oil tank by a steam turbine-driven centrifugal pump capable of circulating approximately 850 gal. of fluid per minute. This turbine is rated at 2800 r.p.m. and is operated at 175-lb. admission pressure. After the pump has picked up the fat oil it discharges through five sets of 19-6 by 216 in. heat exchangers into two live-steam preheaters (20 in. in dia. by 10 ft. 2 in. in length), thence to the combination still and rectifier, entering at a point approximately half-way up this vertical unit. The still is 6 ft. in dia. by 42 ft. high. When the fat oil enters the still it flows onto a tray, then through a down-pipe to the base of the still where the gasoline is stripped from the oil by means of live steam.

The still is operated at a pressure of 40 lb., and is equipped with a dual-recorder that registers the temperature of the fat oil entering and the lean oil



Interior view of the pump house

leaving. A top-temperature recorder-controller holds the top-temperature of the still constant, and also operates the gasoline reflux pump that boosts the reflux back into the top of the still. This pump is a 6 by 6 by 12 unit of the reciprocating type.

The stripped oil, upon leaving the still, returns to and passes through the heat exchangers, going then to the suction of a steam turbine-driven pump of the same size and capacity as that handling the fat oil. This lean oil is discharged through the oil coolers into the tops of the several absorbers, flowing downward over trays equipped with bubble caps, absorbs gasoline from the gas, and is trapped out the bottom through a 6-in. float-control valve into the fat oil tank, the latter measuring 8 ft. by 40 feet.

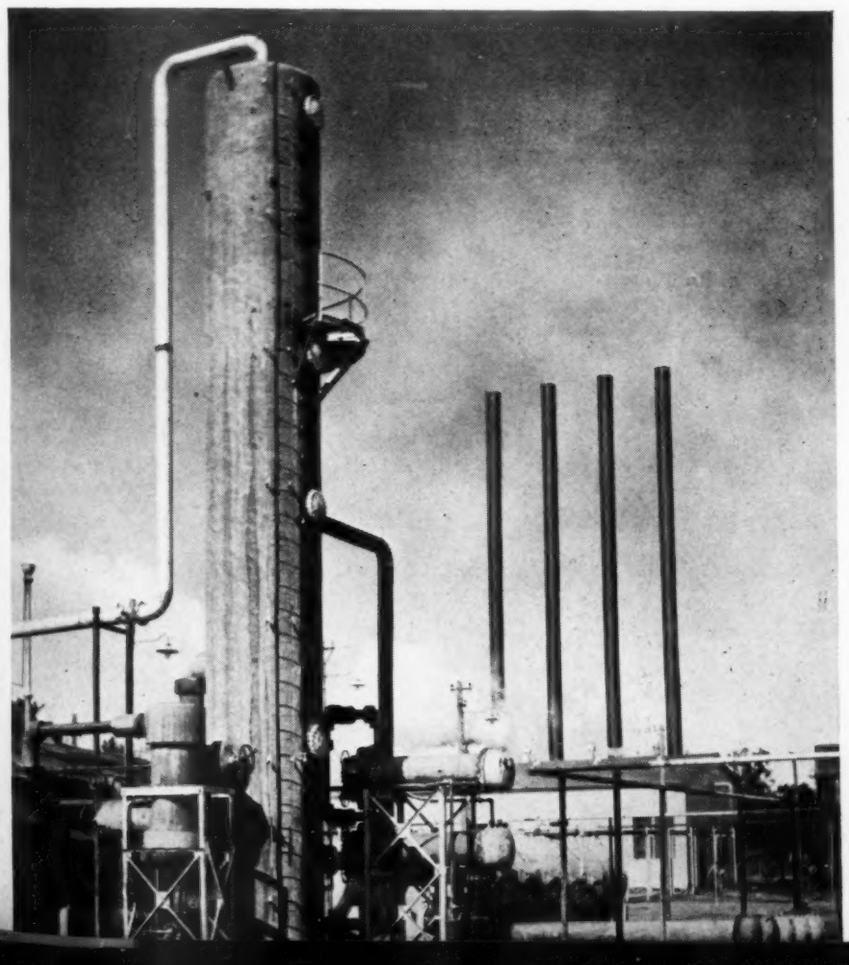
It will be noted that no lean oil tank is provided and this is a departure from the usual practice. Some few gasoline plants have adopted this procedure, but it is not common. The practice most widely used calls for the lean oil to pass from the heat exchangers to a lean oil tank, a pump taking suction from the latter. At the Coltexo plant, as noted, the lean oil goes directly from the heat exchangers to the suction of the pump. This procedure is found entirely satisfactory, according to operating officials of the plant.

In tracing the vapor circuit we find that the gasoline vapors, after being stripped from the mineral seal oil in the combination still and rectifier, pass upward and at the top of the still are led off through a 10-in. line into a set of four coolers situated in the base of the cooling tower, and then to a 6-ft. by 8-ft. vertical reflux tank. Here the heavier constituents of the vapors are condensed, afterwards being picked up by an 8 by 6 by 12 gasoline reflux pump and boosted into the top of the fractionator. The excess from the heavier constituents, together with the uncondensed gasoline vapors, are sent through two sets of single-pass coolers where further condensation is effected. From these coolers the whole passes through an additional set of two single-pass coolers and into the accumulator tank, which is an 8-ft. by 40-ft. horizontal vessel.

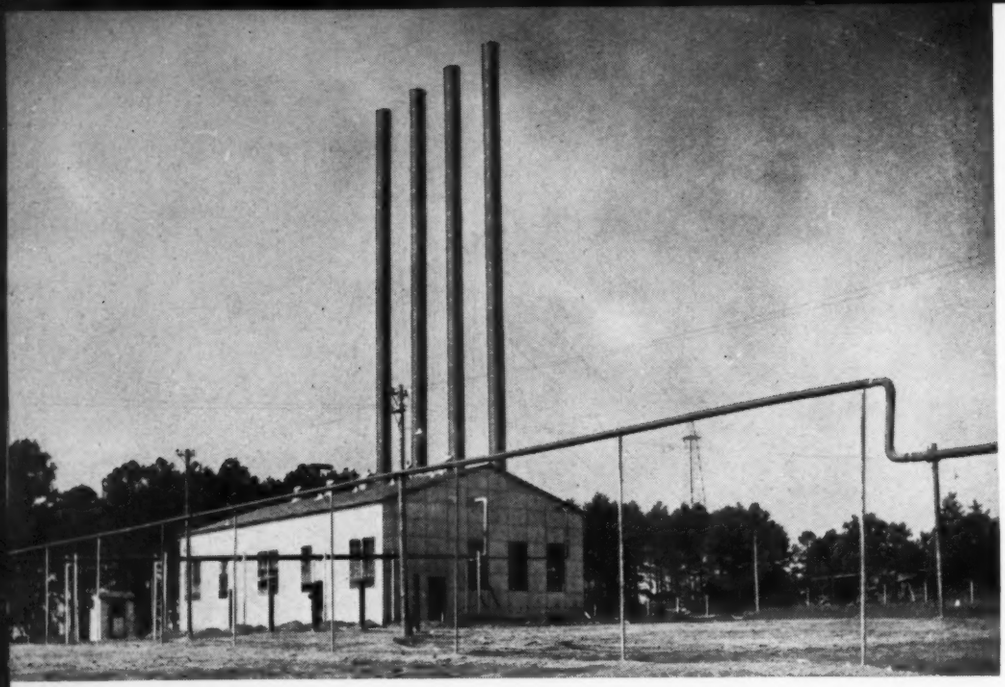
The natural gasoline is picked up from this accumulator tank by a 14 by 4¾ by 12 reciprocating pump and boosted into a set of three small heat exchangers, through a manifold, and into the fractionating column, entering at a point approximately half-way up. The fractionator is equipped with meters, recorders, and recorder-controllers for measuring and recording temperatures, volumes of gasoline, reflux, and vapors. The fractionating equipment is operated at a temperature of 257 deg. fahr. on the kettle, or reboiler, and at approximately 110 deg. fahr. at the top of the column. The operating pressure is 190 pounds.

Gasoline leaving the column proper flows into the kettle where the light ends are boiled off, some of which are condensed and used as reflux, the uncondensed vapors going to the residue system. Fractionated gasoline is trapped through a ¾-in. control valve by a float control, and is then passed through a gasoline cooling coil and sent to storage. Gasoline storage consists of 24 horizontal 25,000-gal. tanks, providing a total capacity of 600,000 gallons. These tanks measure 8 ft. by 41 ft. 7 inches. Two 10 by 10 by 20 reciprocating pumps pick up the gasoline from storage and boost it through two 3-in. lines to a 12-car loading rack slightly less than one mile west of the plant.

All equipment is of a late type, and in designing the plant provision was made for so placing the principal units and auxiliaries as to obtain maximum



Combination still and rectifier, operated at a pressure of 40 pounds



Steam is generated by four large water-tube boilers having 85-ft. stacks

efficiency from their operation. Steam is generated by four large water-tube boilers having 85-ft. stacks. The building housing the steam plant is 40 ft. wide by 76 ft. long by 38 ft. high. All boilers are set in concrete foundations, and brick furnaces are provided. The main steam line from the boiler plant is a 6-in. one. Another 6-in. line branches from this to the still, preheaters, and reheater, while a 4-in. line branches from the main 6-in. to the centrifugal water pumps, and a 2-in. line to the fractionator. Steam lines are carried overhead and are heavily insulated. All condensate from the live steam line, preheaters, and reheater is returned to a 6 by 12 vertical condensate tank by means of a steam trap that discharges into a 3-in. line. This condensate supplies a portion of the boiler feed water. Additional water for the boilers is obtained from a 5000-bbl. tank, flowing by gravity into the condensate tank where it is picked up by the boiler feed pumps. Water is supplied to the boilers at a temperature of approximately 190 deg. fahrenheit. These pumps, of which there are two although but one is employed at a time, are 12 by 8 by 12 simplex plunger type. For emergency purposes provision has been made for boiler feed water to be obtained also from the discharge of the cooling tower's pumps, and from the discharge of the domestic pumps.

The plant's water requirements are supplied by two 330-ft. wells, one situated in the grounds, the other approximately 1000 ft. distant. The water thus procured shows on analysis 2.6 grains of hardness, consequently requires no treating. Two centrifugal pumps driven by 30-hp. motors pump the water from the wells into the bottom flume of the 17-bay enclosed-type cooling tower. The domestic water supply for company cottages is taken off the discharge of these two motor-driven pumps by two 8 by 5 by 12 reciprocating steam pumps and is boosted into an overhead tank, the overflow from which enters a 5000-bbl. emergency tank. The overflow from the latter in turn enters the coil pit of the cooling tower.

Water circulation in the cooling tower is maintained by two steam turbine-driven centrifugal pumps, each having a capacity of 2000 gal. per minute at 75 ft. of head and 2000 revolutions per minute. The turbine has a rated speed of 2800 r.p.m. at 175-lb. steam pressure.

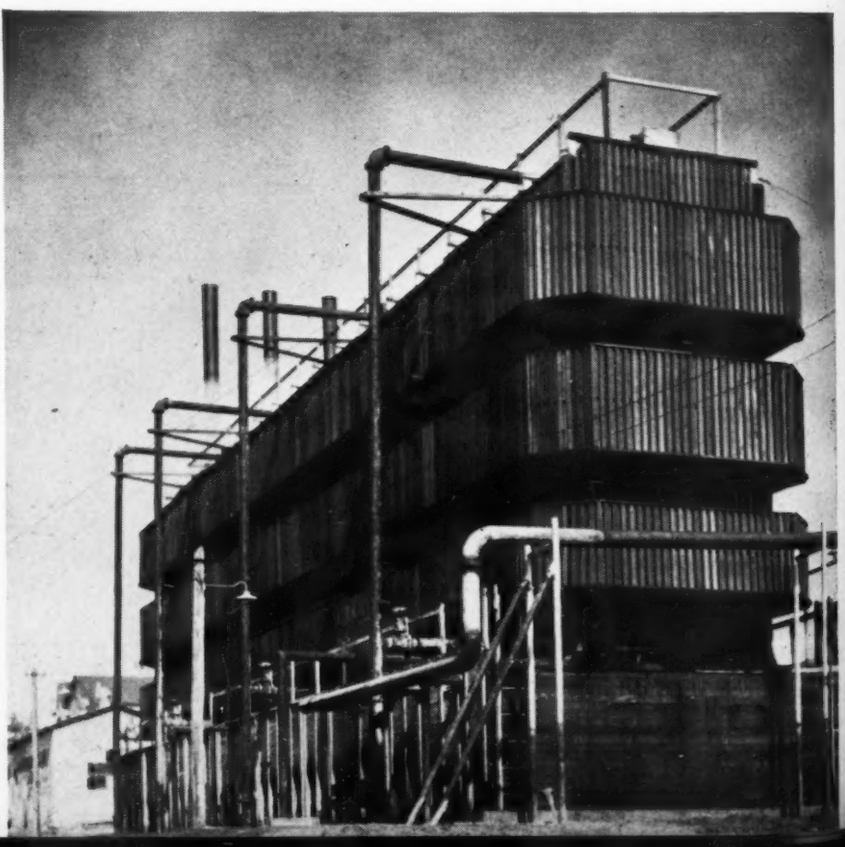
The electrical plant is situated in the boiler house, and consists of a 10-kw. turbine-driven d-c. generator, as well as a 10-kw. unit driven by a 4-cycle gas motor. This equipment provides the electrical needs of the plant other than that required for driving the water well motors and for lighting the company cottages. Power for these purposes is purchased.

Other than the boiler house, measurements of which have been given, principal buildings are the main pump house, 42 ft. in length by 32 ft. in width, an office and laboratory building 16 ft. by 32 ft., a structure containing fire-fighting equipment, lockers for the workmen, and certain tools and miscellaneous equipment. All buildings, except the office and laboratory building, are of steel construction.

Principal fire-fighting equipment consists of one 40-gal. foam generator, together with ample chemicals, and a hose cart with six 50-ft. lengths of hose.

The gas received at the plant for extraction of gasoline is sweet, containing no constituents that necessitate its being treated. The gasoline content is rather low, however, 1000 ft. of gas producing approximately 7/10 gal. of gasoline.

H. E. Means is in charge of the operation of the plant at Rodessa as supervisor. W. E. Reardon, of Monroe, Louisiana, is superintendent for the Coltexo Corporation.



A 17-bay enclosed-type tower for cooling water

Installation in the North Oklahoma City field showing the horizontal receiver tank on the ground alongside the separator

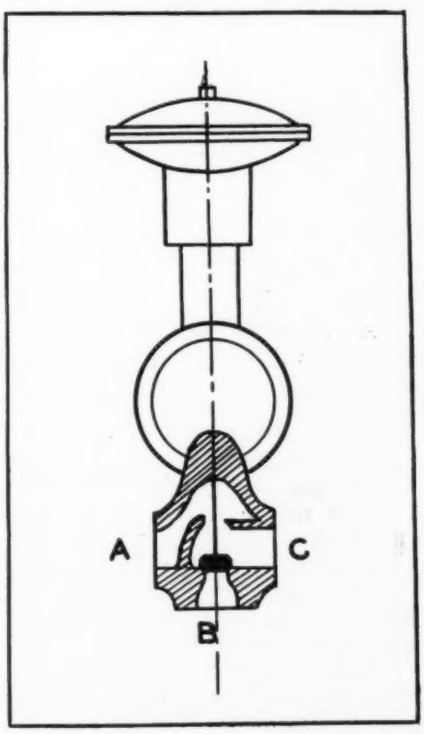
Residue Gas Pressure Used to Elevate Oil from Well Separator to Stock Tanks

By LEO H. TOWERS

IT sometimes becomes a problem to get the oil from the separator to the stock tanks on leases where conditions force the placing of the tanks on a higher level than the separator. It has been the custom either to carry sufficient pressure on the separator to force the delivery of the oil or to elevate the separator on a tower sufficiently high to allow a gravity flow. A system has been developed that permits the separator to be operated at atmospheric pressure or even vacuum and at the same time eliminate the necessity of elevating the separator. Recent installations in the Oklahoma City and East Texas fields have demonstrated the practicability of the method. In these cases the well conditions did not permit a back pressure on the separators if proper flow was to be obtained from the wells.

Not only is the fluid delivered to the stock tanks by this method but an accurate metering of the fluid is obtained. Lease residue gas pressure is used as the force behind the fluid but the system is so designed that no gas is wasted or lost in the operation. The principal parts of the set-up consist of the fluid receiver tank in which is installed a float attached through a stuffing box to a pilot valve on the outside; two 3-way diaphragm-actuated spring-controlled valves; low-pressure regulator and strainer; and the necessary pipe and fittings.

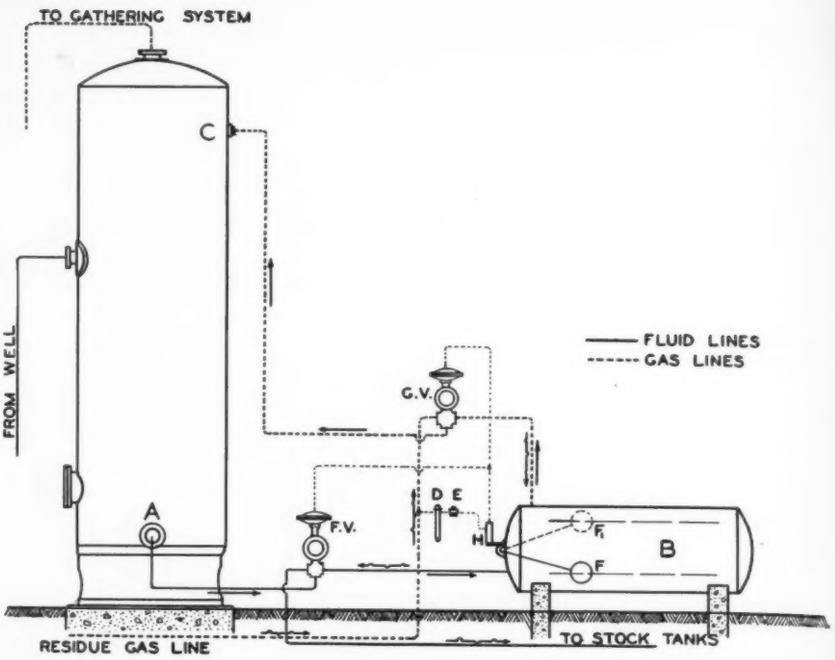
Fig. 1. Sketch indicating the action of the 3-way diaphragm valve



The two diaphragm valves (Fig 1) act as automatic switches, controlling the flow of the fluid and gas through them. They are operated by a low-pressure gas system with the pressure applied or released simultaneously on each valve by the action of the snap-acting pilot valve. With the gas pressure applied to the diaphragm a valve is forced down against the lower valve seat closing the lower (*B*) opening of the valve. Thus with the valve set as shown the flow is from *A* to *C* or vice versa. When the pressure is released a spring assembly forces the valve up against the upper valve seat closing the left (*A*) opening and making the flow from *B* to *C* or vice versa.

In operating the system a complete cycle requires two distinct operations. First, the receiver tank is filled from the separator and, second, the receiver tank is discharged into the stock tank line. A schematic flow chart of the system is shown in Fig. 2. The first half of the flow cycle is indicated by the straight arrows. Oil (or fluid) from the separator *A* flows through

Fig. 2. Flow diagram of the fluid and gas lines from the separator to the stock tanks



the fluid valve *F.V.* and into the receiver tank *B.* As the tank fills with fluid the gas therein is forced out through the gas valve *G.V.* and into the top of the separator at *C,* whence it returns to the gathering system. When the receiver tank is filled and the float *F* reaches the position F_1, it trips open the snap-acting pilot valve *H.* A tap coming off the residue gas line (usually 15- to 25-lb. pressure) is passed through the filter *D* and the low-pressure regulator *E* to this pilot valve. Opening the snap-acting valve exerts a gas pressure on the two 3-way valves closing the fluid connection between the separator and receiver and closing the gas connection between the receiver and the separator. This completes the first half cycle.

From here on the flow is indicated by the wavy arrows. The residue gas line is opened through *G.V.* into the receiver tank *B.* The line pressure forces the fluid out of the receiver tank through valve *F.V.* and into the stock tank line. As the fluid level drops the float again drops to the position *F.* The pilot valve is again tripped releasing the pressure on the two diaphragm valves and completing the cycle.

A counter can be attached to the snap-acting pilot mechanism that will record the number of times the tank is emptied, and the capacity of the tank being known a quick, positive fluid gauge of well production can be had. Several different arrangements for the fluid receiver tank may be made. A vertical tank may be used with the float mounted in the side. Still another arrangement to conserve space may be had by mounting the separator on top of the receiver tank.

Dates Announced for Next International Petroleum Exposition at Tulsa

PRELIMINARY plans for celebrating the 15th anniversary of the International Petroleum Expositon in Tulsa in 1938 were announced by President W. G. Skelly at the A.P.I. meeting in Chicago. The show will be held May 14 to 21, 1938, Skelly stated.

"This will make the tenth Exposition, which used to be held yearly but more recently has been made an every-other-year show at the request of the oil industry which felt there were not sufficient improvements to warrant a display each year and that the expense on the exhibitors was too heavy," stated the president in his announcement.

Available exhibit space has been reserved totaling approximately three-fourths of the 476 booths and outside tracts, although the actual dates were not announced until the A.P.I., said William B. Way, general manager of the exposition, in discussing the plans. Way predicted that with this start the number of exhibits at the 1938 exposition will equal, and likely surpass, the 1936 show.

Attendance, too, promises to be large, for he said that reports from the leading Tulsa hotels stated that a great number of reservations had been made for "the dates when the International Petroleum Exposition is held in Tulsa in 1938."

"Announcement of the dates this far ahead will give exhibitors an opportunity to prepare better exhibits and give the exposition an opportunity to procure better and more extensive scientific displays and to have ample time to publicize the show and thus build up another record attendance," said Skelly.

No rates were announced, but the exposition, although its size and value have increased, has actually decreased rates several times. Way says that 1936 exhibitors will have the refusal of their old space and that new exhibitors and past exhibitors desiring increased space will have their requests filled in the order received.

The exposition will continue as a non-profit institution. It now has a fully equipped plant, paid for, and one especially designed and built for an oil show. Buildings permit the use of exhaust and other outlets through the sides of the building or the roof without injury to the structure.

Way states that the executive committee is working on plans for the next show and also on a special 15th anniversary celebration that will be announced later. The executive committee consists of O. T. Dawson, vice-president of the National Supply Company; Frank Hinderliter, president of Hinderliter Tool Company; W. M. Bovaird, president of Bovaird Supply Company; Clyde Pape, treasurer of Selby Oil and Gas Company; Alf G. Heggem, president of Oil Well Improvements Company; and Messrs. Skelly and Way.

Power Requirements for Rotary Table in Deep Drilling

By

W. C. DREYER*
and
B. H. BERKELEY*

Tests made under one set of conditions show how the load on rotary table varies with the speed of rotation, the bit pressure, and the mud-pump pressure

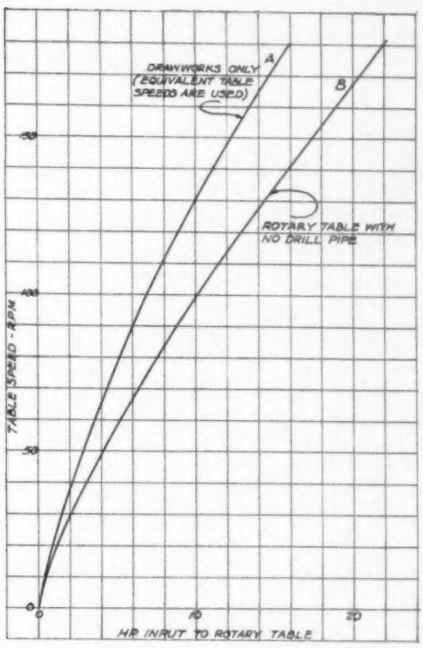


Fig. 1. Curve A shows losses in the drawworks at different speeds with the rotary table declutched. Curve B shows losses in the drawworks and rotary table at different speeds with the drill pipe disconnected.

FEW accurate analyses have been made of the power requirements of a rotary drilling rig. Some studies have been made concerning hoisting and mud-pumping, the power requirements for both being quite large, but very little data on the power required to drive the rotary table are available and the authors know of no information at all showing how this power varies with changes in drilling conditions.

The rotary method of drilling oil wells, as is commonly known, is a boring process employing a bit on the end of a rigid drill stem rotated by the rotary table. Mud is pumped through this stem for cleaning and cooling the bit and for carrying cuttings out of the hole. The rotary table usually is chain-driven from a lineshaft, which in turn is driven by a steam engine or electric motor. When hoisting the drill stem out of the hole for the purpose of changing bits, the rotary table is declutched and the hoisting drum clutched to the lineshaft. Since the engine must develop approximately 1000 hp. for hoisting duty in deep drilling, the rotary table load has no influence on its size. Almost everyone conversant with rotary drilling knows that somewhere around 100 hp. is required for driving the rotary table and such an approximation is close enough where no thought is given to operating efficiency.

Now that more efficient types of rotary equipment are employed and more thought is being given to operating economy, it is desirable that the hp. requirements of all drilling operations be known with greater accuracy. Data on rotary table power requirements are important, for the table is in operation approximately 80 percent of the total drilling time; further, any consideration of separate drive for the rotary table requires definite knowledge of its power requirements.

*Petroleum Division, Westinghouse Electric and Manufacturing Company.

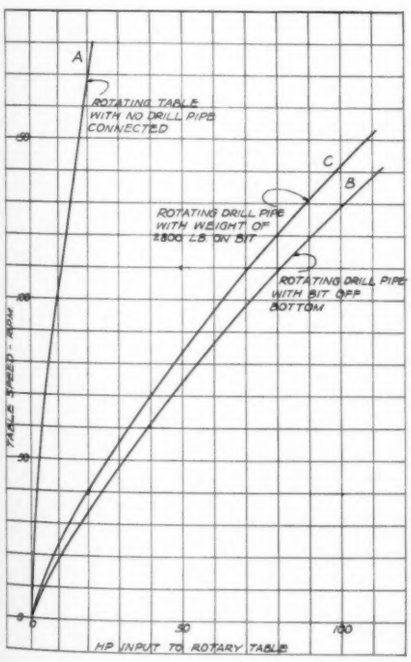


Fig. 2. Curves showing horsepower input to the rotary table at different speeds. Curve A shows the power taken by the surface equipment at no load. Curve B shows the power taken to rotate the pipe in the hole off bottom. Curve C shows the power required to rotate the pipe with a very light weight (2800 lb.) on bit. Attention is called to the greater power required to rotate the pipe off bottom than with some weight on bottom. Curve B is not changed by the mud-pump pressure. Points taken with the pump pressure at 780 lb., 265 lb., and zero lb. all fall on this same uniform curve.

The power required to drive the rotary table is directly influenced by many factors and drilling conditions. The depth of the hole, size of the drill stem, length of hydraulic drill stem, consistency of the mud, crookedness of the hole, and the formation being drilled, all have a direct influence. It is not the purpose of this article to evaluate the effect of these factors on the power taken by the rotary table; rather, it is intended to choose one set of conditions and show how the table load varies with the table speed, with the pressure of the bit on the bottom of the hole, and with the mud pump pressure. Similar tests will be made under other drilling conditions and eventually sufficient accurate data accumulated to draw some conclusions regarding the influence of these other factors.

Equipment and Operating Conditions

A d-c. rig driven by an internal combustion engine was chosen for this study because of the ease with which accurate power and speed measurements can be made and any operating condition obtained and held. The results obtained are in no way affected by the type of rig. Table 1 shows the equipment and operating conditions at the time of this test. These conditions were the same throughout the test, except for about two-ft. increase in depth of hole.

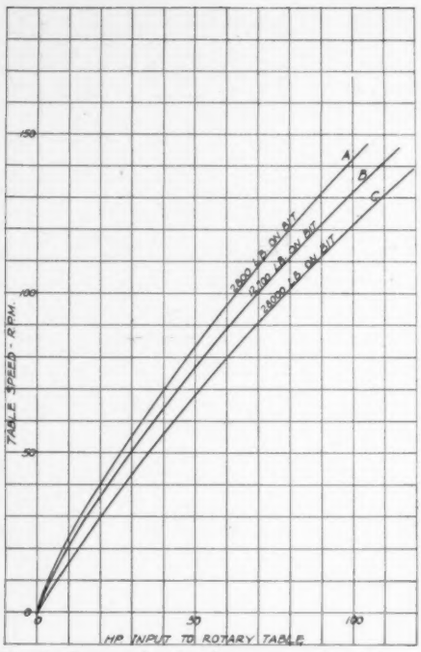


Fig. 3. Curves showing horsepower input to the rotary table at different speeds with 780-lb. pump pressure. Curve A was taken with 2800-lb. weight on the bit. Curve B was taken with 12,700-lb. and Curve C with 28,000-lb. weight on the bit. This range of weights is much greater than is required for ordinary drilling at this depth and formation.

Readings of power input to motors were taken with electric instruments, accurate to within one-half of one percent, and translated to hp. output from actual test curves of the motors. Speeds were taken with tachometer at the motor and translated to table speed and checked by stop watch count when possible. Weight on bottom was obtained from the weight indicator and pump pressure from the pressure gauge at the derrick floor.

Data Taken

Tables 2, 3, and 4 are examples of the data taken. Curves in Figs. 1 to 4 are plotted to give a clearer picture of how the values vary. Although these curves are self-explanatory, attention should be called to several points in connection with them. Curves in Fig. 1 were taken to establish what the no-load losses in the surface equipment were and how they are distributed between the drawworks and rotary table.

TABLE 1
DRILLING CONDITIONS DURING TEST

Depth, 7315 ft.
Size of drill stem, 5 1/16-in. O.D.
Length hydraulic, 160 ft.
Reamers, none.
Size of bit, 9⅞-in.
Type, Hughes HR3.
Holes in bit, Y-shaped slot.
Bit condition, cones in hole 5½ hours.
Mud pump, 7¾ by 18.
Liners, 7¾-in.
Weight of mud, 10.2 lb./gal.
Formation, Woodford shale.
Inclination of formation, 46 deg.
Straightness of hole, 6 deg. off.
Drawworks, 4-Speed unitized.

TABLE 2
READINGS TAKEN WITH PUMP NOT RUNNING

Drawworks Only Table Disconnected		Drawworks and Table Drill Pipe Not Rotating		Rotating Pipe Off Bottom	
Equivalent Table Speed R.P.M.	Table Hp. Input	Table Speed R.P.M.	Table Hp. Input	Table Speed R.P.M.	Table Hp. Input
35.4	2.0	25.1	1.6	41.6	25
46.1	2.6	49.8	4.0	53.4	33.1
62.1	3.7	71.9	6.5	64.1	41.3
83.4	5.9	89.8	8.7	82.1	52.5
105.2	7.4	113	11.9	110	81
172	14.8	180	21.9	167	141.5

TABLE 3
READINGS TAKEN DRILLING WITH 780-LB. PUMP PRESSURE

Weight on the Bit 2800 lb.		Weight on the Bit 12,700 lb.		Weight on the Bit 28,000 lb.	
Table Speed R.P.M.	Table Hp. Input	Table Speed R.P.M.	Table Hp. Input	Table Speed R.P.M.	Table Hp. Input
34.5	16.2	31.6	16.5	22.1	14.1
43.6	22.1	38.5	20.8	30.8	20.7
59	31.9	48.4	28.5	53.9	38.3
73.4	43	69.3	44	68.8	50
102.5	65	88	57.2	87.2	66.2
146	104	146	115	146	126.8

TABLE 4
READINGS TAKEN DRILLING WITH 265-LB. PUMP PRESSURE

Weight on the Bit 5600 lb.		Weight on the Bit 15,500 lb.		Weight on the Bit 31,000 lb.	
Table Speed R.P.M.	Table Hp. Input	Table Speed R.P.M.	Table Hp. Input	Table Speed R.P.M.	Table Hp. Input
42.4	21.6	37.2	20	25.6	18.2
53.4	27.9	47.5	27.5	39.8	25.5
69.2	42.9	59	36.7	62.8	45
88.5	59	82	57	79.5	59.9
118	88	102.5	76.1	97.5	77.9
167	136.8	163	138.7	163	147

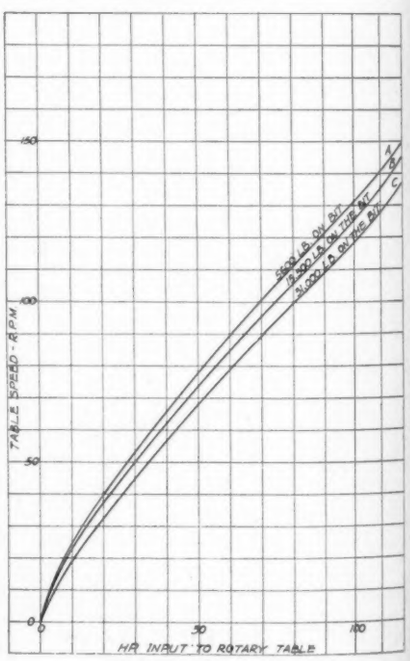
Several interesting points are brought out by curves in Fig. 2. The power required to rotate the pipe with the bit off bottom may be compared with the no-load power input to the surface equipment. This is merely an indication of the surface equipment efficiency and not a true picture, because the losses are changed somewhat by the load.

Curves B and C in Fig. 2 reveal an interesting phenomena. It actually required less power with the bit on bottom than with the bit off bottom. This probably can be accounted for by the fact that the hole was six deg. off vertical and more power was required to flex the drill stem when entirely suspended than when the lower part was supported at the bit. Tests on other wells of different degrees of crookedness substantiate this opinion.

The curve showing power to rotate with the bit off bottom is identical when taken with the mud pump pressure at 780 lb., at 265 lb., and with the pump stopped. In other words, the mud pump had absolutely no effect on these values.

Curves in Fig. 3 show the power input to the rotary table with 780 lb. pump pressure and curves in Fig. 4 with only 265 lb. pump pressure. Comparing these two sets of curves reveals that the principal effect of the pump pressure is its effect on the weight on the bit. When the pump pressure is dropped from 780 lb. to 265 lb., the weight on bottom increases about 2800

Fig. 4. Curves showing horsepower input to the rotary table at different speeds with 265-lb. pump pressure. Curve A was taken with 5600-lb. weight on the bit. Curve B with 15,500-lb. weight on the bit and Curve C with 31,000-lb. weight on the bit.



lb., thereby increasing the hp. required to rotate the table; however, the hp. required to rotate the table at any given speed and weight on bottom seems to be a little more with the lower pump pressure, particularly at higher table speeds. In view of the entire absence of any effect from pump pressure when rotating off bottom, this effect when rotating on bottom cannot be explained from this first set of tests.

Readings were taken of the pump speed and hp. input with the table stopped and the pump pressure maintained at 780 lb., while the weight on bottom was varied from 2800 lb. to 120,000 pounds. This great change in weight on bottom decreased the pump speed and hp. only two and one-half percent.

These data and curves apply primarily to drilling conditions under which they were taken; nevertheless they are valuable, for they show the magnitude of the effect of changes in speed, weight on bottom, and pump pressure on rotary table hp. requirements.

Summary of State Asphalt Specifications Published By Bureau of Mines

A TABULAR summary of state specifications for liquid asphaltic road materials in effect January 1, 1936, has been published by the United States Bureau of Mines, Department of the Interior, in response to requests for such information.

For purposes of the tabulation the United States is divided into five regions. Specifications of each state in each region are classified according to uses for which the materials are intended and a summary is given of the test requirements in each specification. For example, Region 1 comprises Maine, New Hampshire, Vermont, Masssachusetts, Rhode Island, Connecticut, and New York. Maine has no specifications for asphaltic products as the state has not used these materials to any extent. For the other six states in Region 1 the test requirements of specifications in effect in each state on January 1, 1936, are given for prime and tack coats, graded aggregate mixtures, coarse aggregate mixtures, hot surface treatments and seal coats, surface treatments with slow-curing oils, cold surface treatments and seal coats, penetrative treatments without cover, and for patch work. In addition, specifications are listed that are not used or for which no use is stated in the official publication of the state. The same plan has been followed for the other four regions into which the country has been divided.

Statistics published annually by the Bureau of Mines show that use of asphaltic materials for road building has increased markedly in recent years. A large proportion of this material is purchased by state highway departments on specification. Consequently much interest has been manifested in these specifications by manufacturers or potential manufacturers of asphalts, as well as by governmental and other organizations that have not yet adopted specifications, or wish to revise their specifications. Ready availability of information regarding specifications of the various states also is of value in promoting the trend toward uniformity of specification requirements that seem likely to be helpful by increasing the availability of supplies meeting specifications and reducing costs of materials.

The broad subject of essential characteristics of asphalts for various purposes involves many complex considerations that require and deserve study. As a part of its general project of improving the utilization of crude petroleum and its products, the Petroleum and Natural Gas Division of the Bureau of Mines plans to make such investigations of this subject as its resources will permit. This work will be done in coöperation with other agencies working on related problems.

This summary, consisting of 11 sheets, each 18 by 25 in. in size, with cover sheet, is available free of charge upon application to the Information Division, U. S. Bureau of Mines, Washington, D. C.

Results of Study of Brine Disposal in Oil Fields of Western Kansas Presented in Cooperative Report by Bureau of Mines

RESULTS of a study of disposal of oil-field brines in western Kansas, conducted in cooperation with the Kansas State Board of Health, are given in a report just published by the United States Bureau of Mines, Department of the Interior.

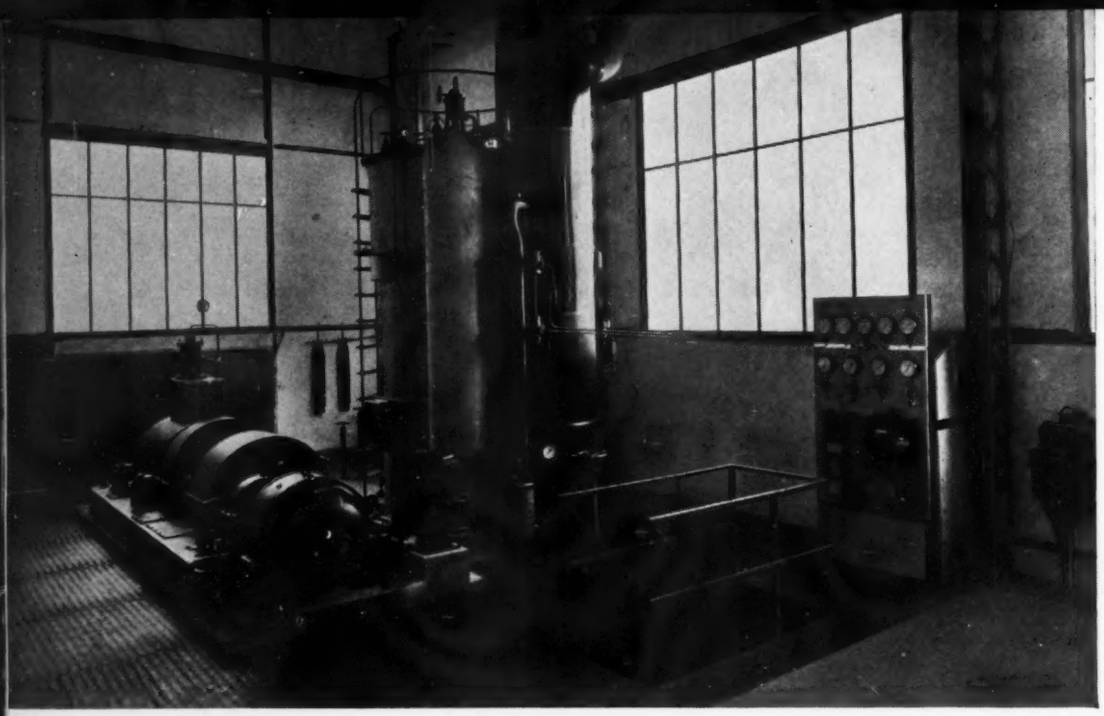
Successful disposal of oil-field brines in Kansas presents an ever-increasing problem to the operators. Two surveys of the oil-producing fields in the Arkansas River drainage area in western Kansas, made approximately one year apart, showed that impounding brine in storage ponds is not a positive means of disposal, because of the permeable character of the soil and the nearness of the domestic water supply to the surface. Two other methods of brine disposal that the study indicates to be applicable under certain conditions are controlled dilution in certain surface streams during flood stage and return of brine to subsurface formations.

The surveys of oil fields in the area under consideration showed that the total number of producing wells increased from 270 to 526 in approximately one year. The average daily oil production per well decreased from 93.5 bbl. to 79 bbl. and the average daily water production increased from 59 to 72 bbl. in the same period.

Surveys of streams in the area showed that only a small part of the high mineral content of the surface water was due to the mineralization by brine produced in the various oil fields. Surveys were made of the chloride content of domestic water from wells in the different fields.

Study of the subsurface disposal systems in operation in the area indicated that most of the difficulties were due to clogging of the formation in input wells by solids suspended or dissolved in the brines. These solids are principally iron sulphide resulting from corrosion of equipment by hydrogen sulphide and calcium carbonate precipitated out of solution. Preliminary corrosion tests were made to determine types of disposal systems in which minimum corrosion might be expected.

The results of this study have been published as Bureau of Mines Report of Investigations 3318, Disposal of Oil-Field Brines in the Arkansas River Drainage Area in Western Kansas, by C. J. Wilhelm, H. M. Thorne, and M. F. Pryor. This report, made possible through cooperation of the Kansas State Board of Health, may be obtained without cost upon application to the Information Division, United States Bureau of Mines, Department of the Interior, Washington, D. C.



Velox steam generator of the *Societé de Gaz et d'Electricité du Sud-Est* at Toulon, France. It generates 55000 lb. of steam per hr. at 300 lb. per sq.in. absolute and 707 deg. fahr., using oil as fuel.

By
HARRY VINOCK

A New Steam Generator and Its Principle of Operation

Something unusual in steam-generating equipment is the subject of this article. The unit discussed is a departure in applying the principles of heat transmission to steam generation for power and process purposes. So novel in design and operation is this unit, so startling in the reported results and efficiencies obtainable, that it is presented here in some detail.

STEAM is important in the oil refining industry, both as a source of power and for process uses. Most of the power produced in industry being steam power, any means of generating steam more economically, and by burning oil or gas at the expense of other fuels, is of interest to the refiner. It is in this connection that the Velox steam generator, an entirely new device for the generation of steam, is of interest not only because of its characteristics as a steam-generating unit, but also because of its radically new principle of heat transmission, which perhaps may be profitably adapted to various types of refining equipment for the better and more complete utilization of heat.

It is in the substantial improvement of combustion and the rate of heat transmission that the Velox boiler differs from other steam-generating units. Its name refers to the high velocity of the flue gases used to obtain exceptionally high heat transmission, as well as to the property of producing steam in a few minutes from cold and of the unit adapting itself to widely varying loads in a few seconds. This flexibility feature should be important in refineries where the power and process steam demands may vary widely.

The development of this boiler is founded on studies and research work carried on some years ago in connection with the supercharging of Diesel engines and with the design of a gas turbine. Heat losses that occurred in cooling gas-turbine nozzles in which the speed of the gases was far in the excess of the velocity of sound could only be explained by heat-transfer figures far above anything that could be expected by extrapolating existing formulas. There was then conceived the idea of utilizing this feature, which in the gas turbine produced a heavy loss, to advantage by applying it to a steam generator.

Intensive research work with a small combustion chamber and a single tube in which velocities up to and exceeding the velocity of sound were attained gave the interesting results shown in Fig. 1, revealing that if such velocities could be economically obtained and applied to steam generators, the heat-transmitting surfaces could be reduced to about one-tenth of those of existing boilers with a corresponding saving in space and weight. The realization of such gas velocities causes pressure drops far in excess of those occurring in ordinary boilers, and combustion under pressure in a tight chamber had to be resorted to. This pressure-firing system and other features perhaps may be adapted to many primary heating installations in refineries.

Description and Operation

The steam generator involves the following unusual features: combustion under pressure, high flue gas velocities, high rate of heat transfer, forced circulation of water, steam separation by centrifugal action, and air pressure for pressure-firing produced by exhaust gas-turbine-driven blower. The method as finally developed is indicated by diagram in Fig. 2.

Combustion. Free air is taken in by the turbine compressor (12) and discharged into the combustion chamber (6) at about 35 lb. per sq. in. absolute. The geared motor (14) provides power for starting and regulation and to make up for the small bearing and radiation losses of the turbine-compressor set.

Fuel. The oil pump (10) feeds oil to the airless injection burner from tank (9) under a pressure of 300 lb. per sq. in. gauge. When gas is used as the fuel it is introduced under pressure by a turbine compressor driven by a flue-gas turbine.

Flue Gas. The flue gases pass downward through the cylindrical combus-

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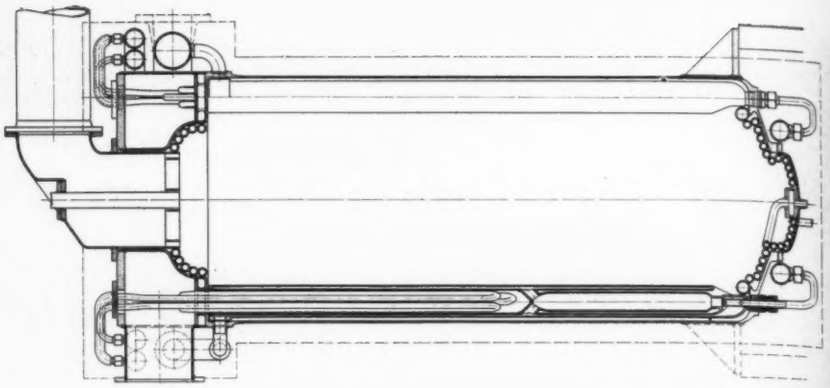
Section through combustion chamber with evaporator and superheater element of the Velox steam generator



tion chamber (6), meanwhile giving up part of their heat by radiation to the external walls of the evaporator tubes that surround the combustion chamber, and then at enormous velocities of about 610 ft. per sec. pass upward through the flue tubes of the evaporator elements where most of the heat transfer takes place by convection. The gases then enter the superheater (7) at a temperature of 1500 deg. fahr. and pressure of 33 lb. per sq. in. abs., and leave it at approximately 900 deg. fahr. and 31 lb. per sq. in. absolute. After expanding through the gas turbine (11) the gases are at approximately 700 deg. fahr. and 16.5 lb. per sq. in. absolute. All work done in the turbine except negligible radiation and bearing losses reverts to the system through the blower preheating the air. Finally the gases exhaust through the feedwater heater (3), which forms part of the chimney, and the chimney itself into the atmosphere at about 200 deg. fahrenheit.

Water. The feed pump (2) delivers the feed from tank (1) through the economizer (3) into the separator (4) where it mixes with the boiler water, which is kept in continuous circulation by pump (5), through the combustion chamber and evaporator tubes back to the separator at the rate of ten times the full-load evaporation, thereby insuring good heat transfer on the water side and moderate temperatures of materials throughout the boiler.

Construction

The evaporator tubes lining the wall of the combustion chamber to protect it from radiant heat are bolted to the wall at the outlet end and are guided so as to expand freely on the inlet end. Thus they can be removed from the chamber with ease. The inner tubes, which have nozzle-shaped inlets, show a remarkable diffusing action. They tend to re-transform kinetic energy into pressure due to the rapid cooling of the passing gases with a corresponding reduction in volume. The flue gases pass the superheater elements in a longitudinal direction, the tube heads being streamlined so as to reduce pressure losses.

In the most recent design the superheater elements are placed inside the evaporator tubes and, therefore, inside the combustion chamber. This gives a very compact and neat design as shown in Fig. 2.

As previously mentioned, the overall efficiency of the supercharging set is of great importance. The boilers are now fitted with reaction turbines having three to four stages and axial blowers that have been specially developed for this purpose. The overall efficiency is of the order of 83 (turbine) x 73 (blower) = 60 percent.

To reduce weight the gas-turbine casing is entirely welded, and the blower casing is built up of a blade-carrying cast-iron body and welded air chambers. Both machines have heavy shafts so as to run below the critical speed. As their speed varies proportionately with the load, they must be able to run continuously at any given speed between no load and full load.

The gases flow along the tubes of the preheater in the same manner as they do in the superheater. The elements of the preheater therefore are of similar design to those of the superheater.

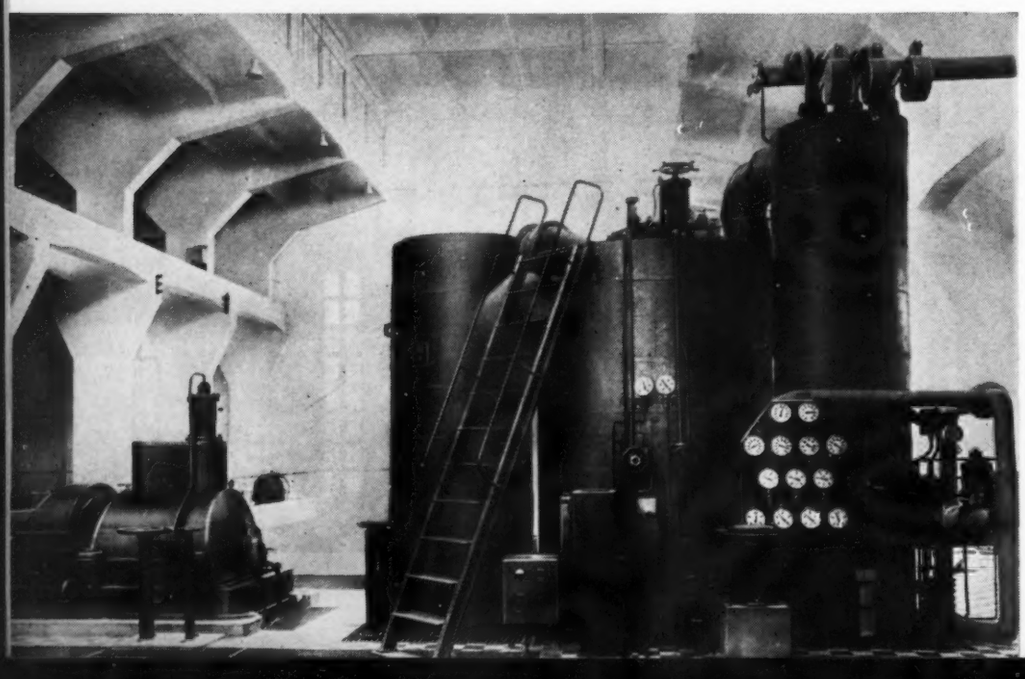
Governing System

The quantities that have to be controlled in boiler operation are: the supply of feed water, the supply of fuel, and the supply of combustion air.

The feed water supply is regulated so as to maintain a constant level in the boiler. The supply of fuel and combustion air are regulated according to the steam demand on the boiler through the medium of a steam-pressure regulator; if the steam demand increases the pressure tends to fall, whereupon the automatic regulating device causes the admission of more fuel and air and re-establishes the original pressure.

The various devices for maintaining the feed water level, and governing the amount of oil and air, are shown respectively by A, B, and C of Fig. 3. An oil pump connected to the motor, driving the circulating pump already mentioned, supplies oil through the pipe (13) to the different governors. A plug (12) reduces the pressure in a variable degree according to the position of a leak-off valve (14). In (A) the position of this valve is governed by a water column acting against a spring so as to keep the water level constant by varying the pressure beneath the piston (15), which governs the feed valve (2).

In the governing system (B) regulating the amount of fuel oil, the leak-off valve (14) is governed by the pressure of the steam in such a way that with a falling steam pressure the valve closes and raises the oil pressure under piston (16), thus opening the fuel valve (4).



Velox steam generator of the Palestine Electric Corporation, Ltd. at Haifa Power Station, Palestine. It generates 76,000 lb. steam per hr. at 385 lb. per sq.in. absolute and 842 deg. fahr., and burns fuel oil.

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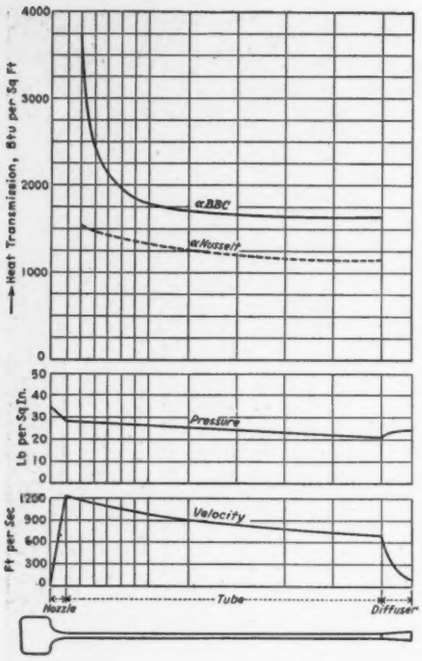


Fig. 1. Heat transmission, pressure drop, and velocity of flow in a tube connected to a small combustion chamber

The governing system (C) tends to establish a constant ratio between the amount of fuel and the amount of air; both the fuel valve and the air valve work on the same leak-off valve (14), and maintain their relative positions as long as the ratio of the two is constant. Any deviation from this ratio displaces valve (14) with a corresponding change in the oil pressure beneath piston (17), adjusting the power of the auxiliary drive, which may be an electric motor or a turbine.

Performance

Due to the small mass of material taking part in heat transmission and to the small water-storage capacity, which purposely has been kept to a minimum, the boiler can be set to work in an unusually short space of time. Fig. 4 shows how steam pressure, temperature, and quantity can be raised to full-load conditions in less than five minutes. Load variations after the boiler is operating can be dealt with so rapidly by the automatic governing system that variations from half to full load or vice versa that take only about 20 seconds, can be met. Even when full load is cut out suddenly, no blowing occurs. In a refinery, where the requirements for process and power sometimes are likely to change suddenly, this is an important feature.

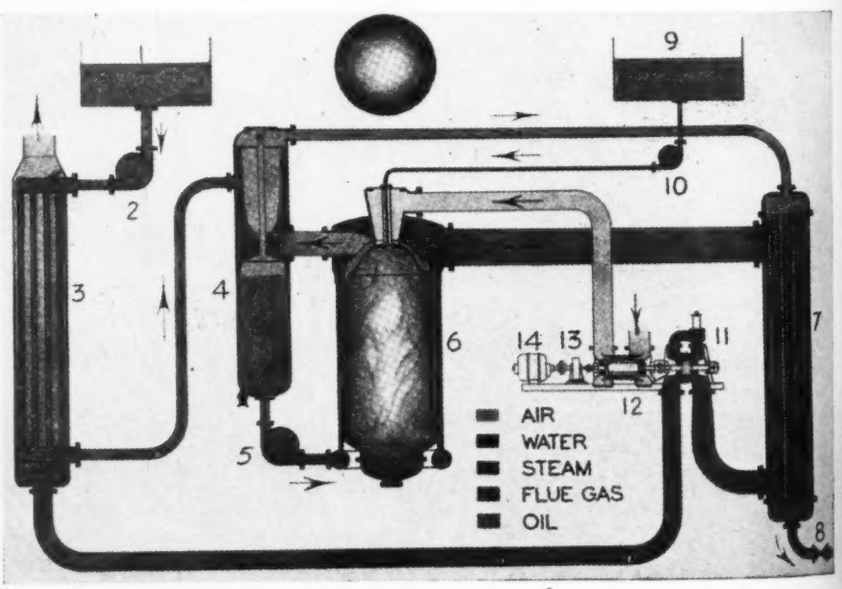


Fig. 2. Flow diagram of Velox steam generator. 1. Feed water supply. 2. Feed water pump. 3. Economizer. 4. Separator. 5. Circulating pump. 6. Evaporator. 7. Superheater. 8. Steam outlet. 9. Oil fuel supply. 10. Oil fuel pump. 11. Gas turbine. 12. Air compressor. 13. Reduction gear. 14. Motor.

Special Features

Pressure Firing. The combustion air and, with gas firing, the fuel also are compressed by a blower and forced into the combustion chamber at a pressure of 28 lb. to 50 lb. per sq. in. abs. and burned at this pressure. This closely approximates the conditions encountered in some internal combustion engines. The pressure drop of the flue gases in pressure-firing produces turbulence in the combustion air mixture and imparts velocity to the flue gases while a large part of the drop is absorbed in the gas turbine that drives the boiler.

Gas Turbine. The energy required to drive the gas turbine is derived from the flue gases and is returned, minus radiation and bearing losses, entirely to the boiler by means of the work done in the blower in the form of heat given to the combustion air. This makes possible pressure firing with practically no external power requirements. Due to the compression the air is heated to about 250 to 330 deg. fahr. and the blower thus replaces the air preheater.

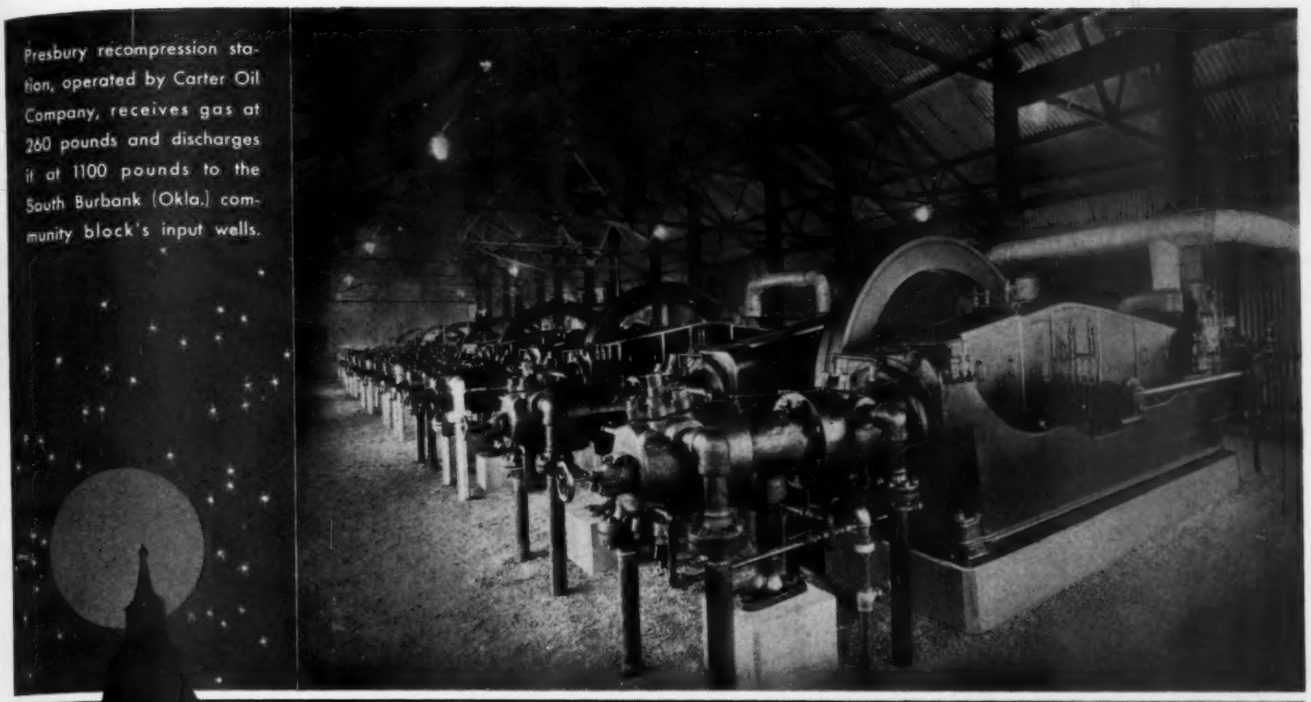
High Flue-Gas Velocities. The velocity of the flue gases in the evaporator tubes is approximately 650 ft. per sec. and greater, and in the superheater and feedwater heater in the region of 330 ft. per second. Very high velocities also are maintained in the burner in order to obtain adequate turbulence and a good mixture of air and fuel. Quite possibly it is this feature of high flue gas velocities and the resulting high heat transmissions and high combustion chamber outputs that is of the most significance to the oil industry, inasmuch as it may affect the design of primary heating devices such as furnaces.

Large Heat Transmission. The heat transmission by radiation resulting from the high-pressure and high-combustion temperature, and the heat transmission by convection resulting from the high pressure and high velocities, amount to as much as 110,000 B.t.u. per sq. ft. per hr. at the walls of the evaporator tubes and inner heating tubes of the evaporator part, which corresponds to an evaporator output of 100 to 130 lb. of steam per hr. per sq. ft. of heating surface. The heat transmission in the preheater also is considerable, being 10 to 20 times that of an ordinary boiler.

High Combustion Chamber Output. As a result of the combustion under pressure and the good mixture that is formed, for which purpose special burners have been evolved, combustion chamber outputs up to 900,000 B.t.u. per hr. per cu. ft. are obtained, so that the combustion spaces need to occupy only one-tenth or even less of the space ordinarily required for the combustion chamber. These high combustion chamber outputs are obtained with a minimum of excess air.

Forced Water Circulation. By means of a circulating pump high velocities also are achieved on the water side of the heating surfaces. The quantities of water in circulation are always ten to 20 times greater than the quantity of water to be evaporated. The water capacity of the boiler is equal to about one-seventh to one-tenth of the maximum hourly steam quantity and thus is high enough to accommodate any sudden load without creating a disturbing change.

Mechanical Separation of Steam. The steam-water mixture in the evap-



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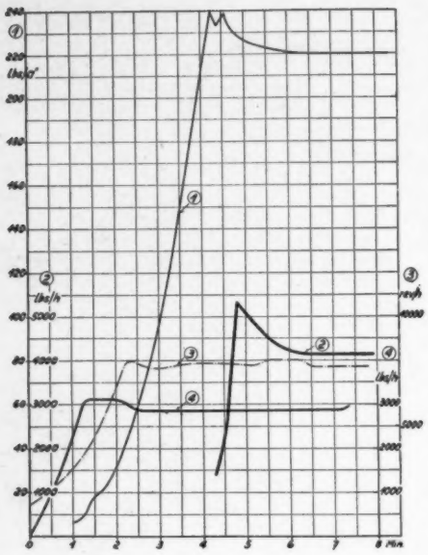


Fig. 4. Starting curves of a Velox steam generator. (1 = steam pressure in lb. per sq. in.; 2 = evaporation in lb. per hr.; 3 = revolutions of blower and gas turbine, r.p.m.; 4 = fuel consumption in lb. per hr.)

orating tubes is given a high velocity by the circulating pump and is then forced through nozzles into a vertical drum where separation of the steam and water takes place by centrifugal action. The separation capacity of this centrifugal separator is approximately 100 to 200 times greater than that of normal drums.

Completely Automatic Governing. Water level, fuel supply, and combustion air are all automatically regulated. Oil under pressure is used to carry the governor impulse to the pistons of the regulating valves. The governing is direct and of a precision hitherto only attained in internal combustion engines. All governing can be done by hand, but during service it is effected entirely automatically. There also are provided safety devices that shut down the boiler if anything should happen to the water circulating pump or the water level should rise above or below certain predetermined levels.

Absence of Brickwork. Protection against the radiated heat or against contact with hot gases is entirely by means of metallic heating surfaces. There is no brickwork to be destroyed by heat or rapid changes of temperature. Due to the small overall dimensions of the boiler radiation losses are considerably reduced.

High Efficiency. With oil firing and for stationary and merchant marine boilers the thermal efficiency amounts to 94 to 96 percent. The plant efficiency, including all auxiliary machinery except boiler feed pumps, is 90 to 93 percent. For gases of poor quality or for Naval and locomotive boilers, which, due to further reduction in weight, have smaller preheaters, the efficiency is two to three percent lower. The efficiencies remain practically constant from one-fourth to full load. In conjunction with a turbine the boiler can compete successfully with the Diesel in some of the lower power ranges.

Immediate Automatic Adaptation of the Firing and Feedwater to Suit Steam Requirements. Depending upon the kind and size of the auxiliary and governing motor, the load can be increased from one-fourth to full load without any appreciable pressure drop in from 12 to 40 seconds, and unloading can occur over the same range without blowing the safety valve.

Rapid Starting. As a result of the small masses involved, the absence of refractory brickwork, and the positive supply of fuel and combustion air, the boiler can be brought from a cold condition up to full load in four to eight minutes, depending upon the size and loading capacity of the auxiliary motor.

Small Space Requirements. This generator occupies only about one-fourth the space of a conventional boiler. The most important advantage of the small amount of space required is the possibility of the compact arrangement of boiler and prime mover, whereby steam lines, pipe fittings, and other accessories can be dispensed with, the whole installation being simplified, and the boiler house completely eliminated.

Small Weight. The weight of the complete boiler plant including all auxiliary machinery is about one-tenth that of the conventional boiler of similar capacity. Lighter foundations can then be used.

Rapid Erection on Site. The boiler can be completely erected and tested in the shops of the manufacturers so that erection on the site requires but a short time; only a light foundation is needed and no brickwork. Due to the comparatively high exhaust gas velocities that are admissible, it is possible to keep exhaust gas-piping and flues small; since the draft is mechanically induced, a Diesel stack is sufficient in place of a chimney.

At the present writing this steam generator is being made exclusively in Switzerland, but the manufacturers foresee the time when production will start in the United States. No American manufacturer as yet has obtained patent rights on the boiler or its principle of heat transmission.

The first Velox unit for the United States has been ordered significantly enough by a large refinery in the East; it probably will be operating by the time of the publication of this article. It is designed to operate on either fuel oil or refinery gas and has a capacity of 50,000 lb. of steam per hour at a pressure of 450 lb. per sq. in. abs. and at a temperature of 940 deg. fahrenheit.

Note: The author wishes to acknowledge the assistance of Brown Boveri and Company for supplying information and illustrative material for the preparation of this article.

References: "The Velox Steam Generator for Land Purposes," Brown Boveri and Company.

"The Velox Steam Generator — Its Possibilities as Applied to Land and Sea," Adolphe Meyer, *Mechanical Engineering*, August, 1935, p. 469.

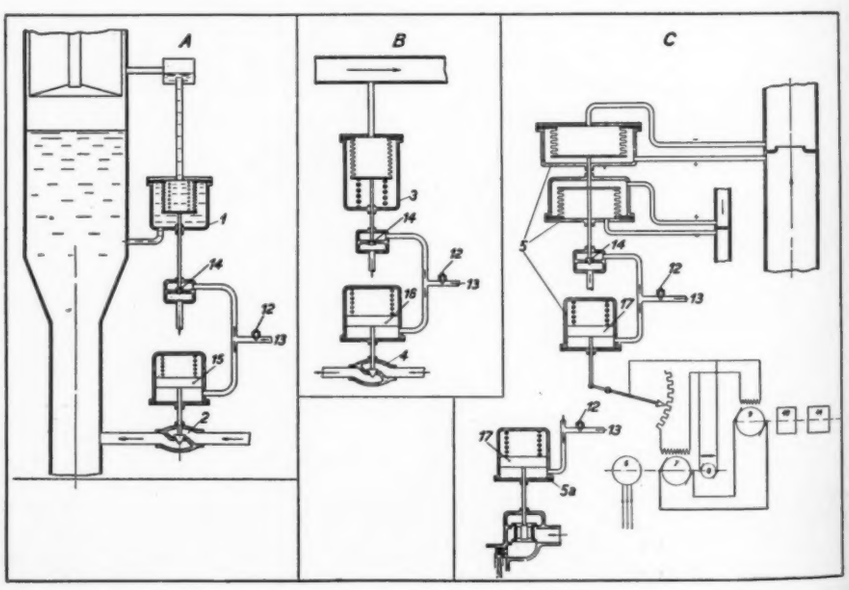
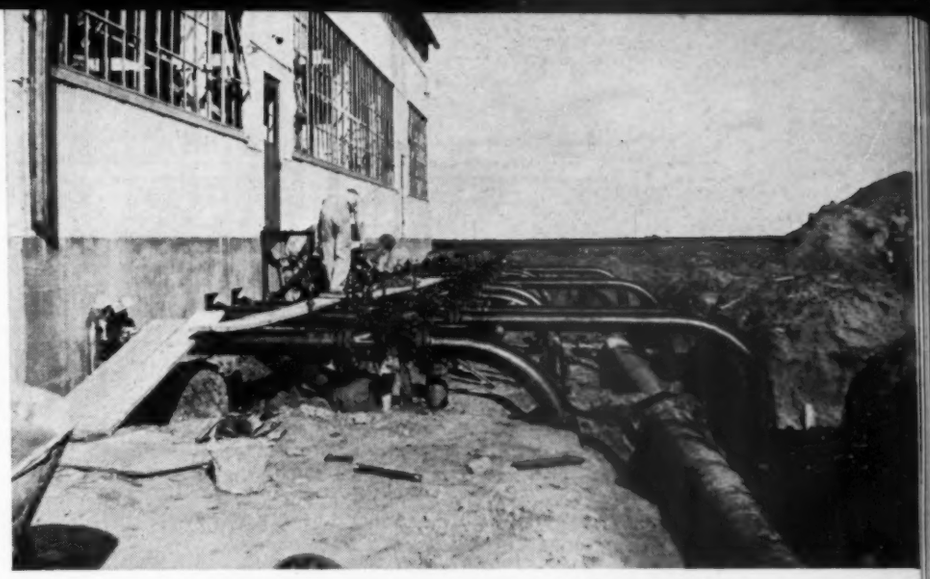


Fig. 3. Diagrammatic outline of automatic governing system

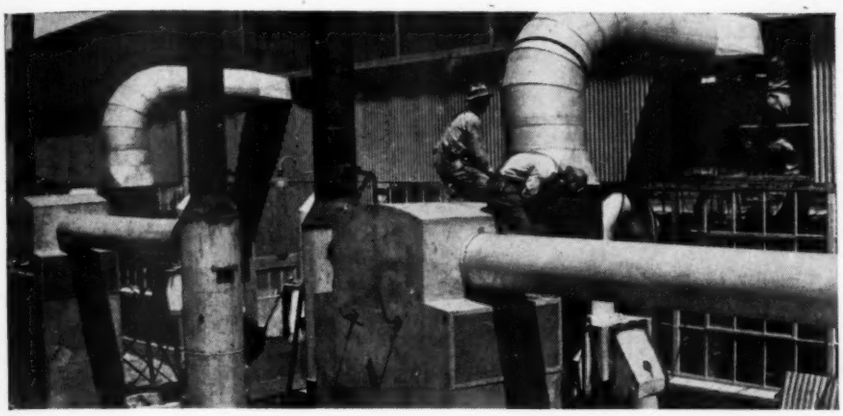


Gas suction and discharge piping at main building, Haven station

Seven compressor stations, absorption gasoline plant and dehydration unit, submerged river crossing, and enlargement of existing compressor stations comprise main additions to Panhandle Eastern Pipe Line Company's system—many engineering details involved in selecting proper type equipment to suit varying operating conditions along line.

Increasing Gas Transmission System's Facilities •

By J. STANLEY STEVENSON
Chief Engineer, Panhandle Eastern Pipe Line Company



Combination equipment used for cooling engine exhausts and supplying conditioned air to compressor building, Liberal station

THE completion of Michigan Gas Transmission Corporation's 230-mile 22-in. pipe line from Zionsville, Indiana, to the River Rouge plant of the Detroit City Gas Company early in July was the first major step in the project to extend natural gas service to Detroit. Following the turning of gas into District No. 1 on July 9th, a change-over force numbering more than 2400 trained men was engaged to adjust customers' appliances in 27 districts, with the schedule calling for the entire city to be changed over to natural gas by the middle of November.

At the time main line compressor station facilities of the Panhandle Eastern Pipe Line Company consisted of three stations—a 5000-hp. station near Liberal, Kansas, a 5000-hp. station 40 miles south of Kansas City, near Louisburg, Kansas, and a 4000-hp. station at Glenarm, Illinois. The signing of a contract in 1935 providing for the transportation of natural gas to Detriot for resale made it necessary to provide additional compressor stations and other facilities along the 856 miles of main line from Sneed Station in the Texas Panhandle to the Indiana state line.

Numerous studies of pipe line capacity and horsepower were made in the fall of 1935. Following four months of design work and preparation of basic plans, contracts were let late in April for the construction of seven new compressor stations. Later additional contracts were awarded for the addition of 2000 hp. to an existing station, the construction of a combination gasoline-absorption and gas-dehydration plant, the laying of additional gathering lines, the drilling of additional wells, the erection of operators' residences and miscellaneous buildings, and the construction of a double 12-in. river crossing. The river crossing across the Mississippi River at Louisana, Missouri, was to supplement the existing single 22-in. line supported on the Champ Clark memorial bridge.

Compressor Station Facilities

A total of 26,000 hp. was added by the construction of new stations, which, with the 2000 hp. installed in an old station and the existing 14,000 hp., provides a total of 42,000 hp. available along the main line of the Panhandle Eastern's system between the Texas Panhandle and the Illinois-Indiana state line. The hp. of existing stations and that made available by erection of new stations and additions to old stations is shown in the following tabulation:

Station	*New Hp.*	*Present Hp.*
TEXAS		
Sneed	2600	-----
KANSAS		
Liberal	2000	5000
Greensburg	3900	-----
Haven	3900	-----
Olpe	3900	-----
Louisburg	----	5000
MISSOURI		
Houstonia	5200	-----
Centralia	3900	-----
ILLINOIS		
Pleasant Hill	2600	-----
Glenarm	----	4000
Totals	28,000	14,000

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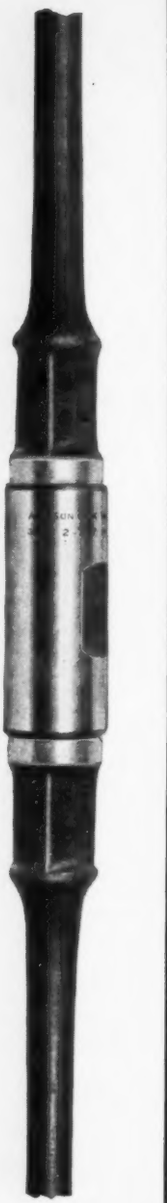

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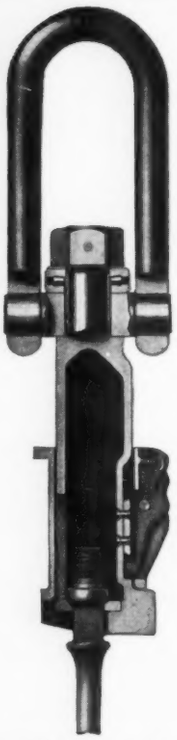

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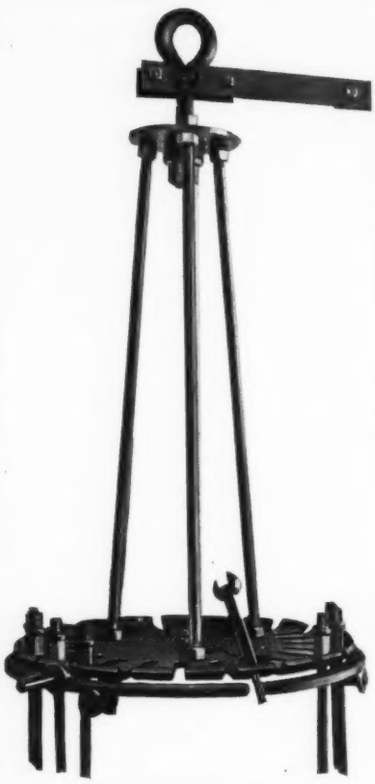

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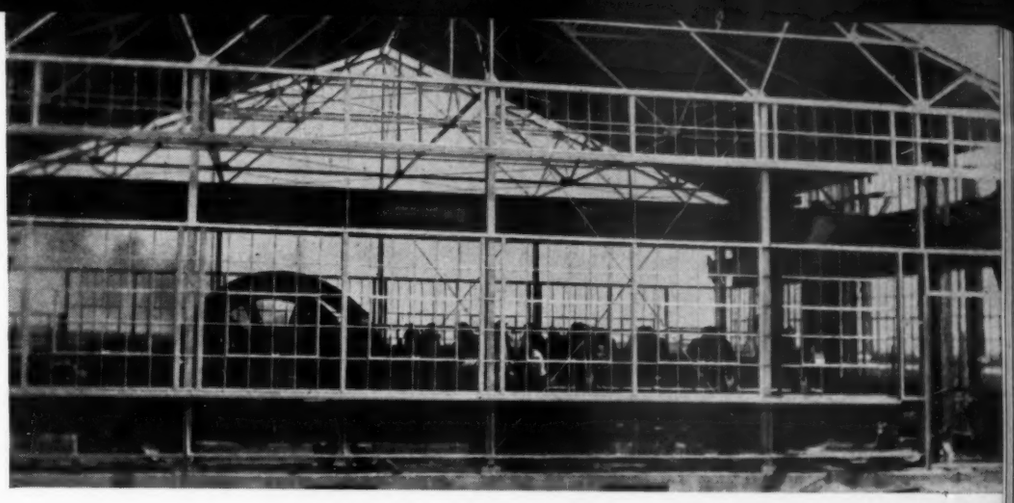

Main building at Sneed station prior to installation of siding, showing main unit erection and traveling crane

In addition to the above hp. requirements of the Panhandle Eastern's system a 2600-hp. station known as Wabash Station has been constructed near Montezuma, Indiana, by the Michigan Gas Transmission Corporation in order to maintain adequate delivery pressures at Detroit this winter. Another station, to be situated near Tuscola, Illinois, will be added later by the Panhandle Eastern, and it is expected that it will be necessary to provide additional units at most of these stations next summer.

Cooper-Bessemer 1300-hp. units were installed at the Sneed, Greensburg, Haven, and Houstonia stations—a total of 12 units. Eight Worthington Pump and Machinery Corporation units of similar type and the same hp. were installed at the Olpe, Centralia, and Pleasant Hill stations. These gas-driven units are 24-in. by 36-in., horizontal, twin-tandem, double-acting, being front-connected to 15-in. by 36-in. compressor cylinders. The two main units added at the Liberal station are Cooper-Bessemer 1000-hp., 21½-in. by 36-in., similar in other respects to the 1300-hp. type. A maximum discharge pressure of 450-lb. gauge was used in calculating the hp. requirements for the first year of operation of the new stations. It is believed that ratios of compression will vary during the first year's operation from 1.3 to 2.2. The average ratio will be approximately 1.55, although a somewhat higher average should be maintained after additions have been made to all stations.

Station buildings are of structural-steel frame, with corrugated asbestos-cement siding and roofing. The main compressor buildings are 72 ft. wide, varying in length from 56 ft. for a two-unit station to 112 ft. for a four-unit station. The main buildings have full basements, with a 6-ft. clearance under all piping. The operating floors are established at elevations permitting basement windows to be entirely above finished grade, eliminating window wells. A 24-in. reinforced-concrete mat under the entire basement of each main building provides a secure footing for main unit blocks. These buildings are equipped with crane beams and rails on which a 12-ton single-span crane will travel. Other buildings consist of an auxiliary building, 36 ft. by 128 ft., a meter and regulator building, 12 ft. by 24 ft., a garage and storage building, 22 ft. by 50 ft., well houses with derricks, and the station superintendent's residence. The residence is a modern, five-room, frame cottage with full basement. It is heated with a gas furnace.

The auxiliary building at each station houses two auxiliary gas engines, a two-stage motor-driven starting air compressor arranged for multi- V-belt drive, suitable for delivering approximately 55 cu. ft. per min. against a maximum pressure of 250 lb. per sq. in.; a gas engine-driven, two-stage air compressor unit capable of delivering approximately 30 cu. ft. per min. against 250-lb. pressure; six 700-gal. per min. horizontally split-case, double-suction, single-stage, centrifugal water pumps direct-connected to splash-proof motors, suitable for operation against heads of approximately 65 ft. and 85 ft.; cubicle switchboards, a zeolite water softener, storage batteries, racks and chargers; and a Kewanee Type "C" boiler for heating station buildings during periods when the main units are not operating. Machine tools are installed in this building. Other features include a combined wash, toilet, and locker room, a storeroom for small parts and supplies, and the superintendent's office. The office is ceiled and soundproofed.

The auxiliary engines are vertical type, direct-connected to 125-kw. generators. A 120-208-volt distribution system carries the 3-phase, 60-cycle current throughout the plant.

Worthington pumps direct-connected to 20-hp. and 25-hp. General Electric motors are used to circulate the jacket cooling water. Fluor Aerator type atmospheric cooling towers provide the cooling medium for the jacket water and the hot gas in the discharge line, which can be cooled under the severest temperature conditions to 90 deg. fahrenheit. A 75,000-gal. elevated water storage tank, manufactured and erected by the Chicago Bridge and Iron Works, floats on the jacket water line between the circulating pumps and the main units. Raw water direct from wells is pumped through a Permutit zeolite water-treating plant. A single unit at each station provides capacity for treating 300 gal. per min., with sufficient shell height to give double capacity by increasing the thickness of the zeolite bed.

Grade "B" seamless line pipe is used throughout, Series 30 forged steel Vanstone flanges and flanged fittings being installed for high-pressure gas and air service, with Series 15 used for fuel gas, water, steam, etc. With few exceptions piping was shop-fabricated. All high-pressure lines were electric-welded and reinforced in the field.

Water is supplied at each new station from wells situated on the station site, except at Haven and Olpe where it was found necessary to leave the stations to

Gas piping at cooling tower, Haven station

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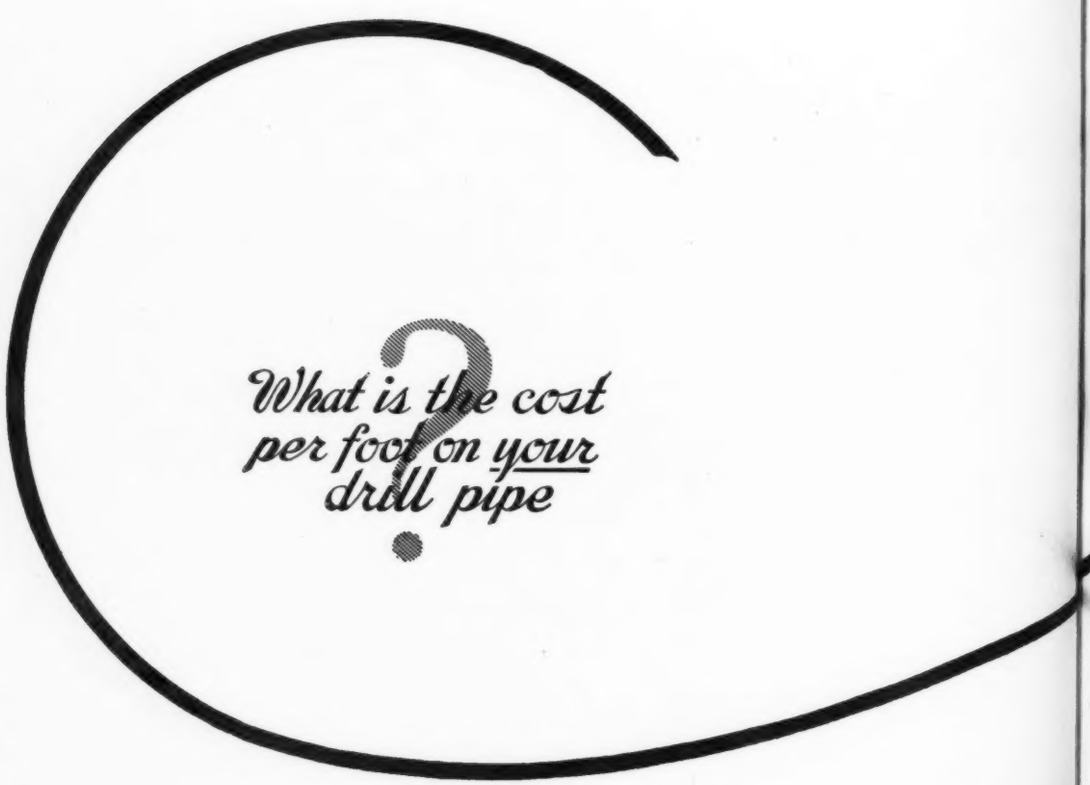

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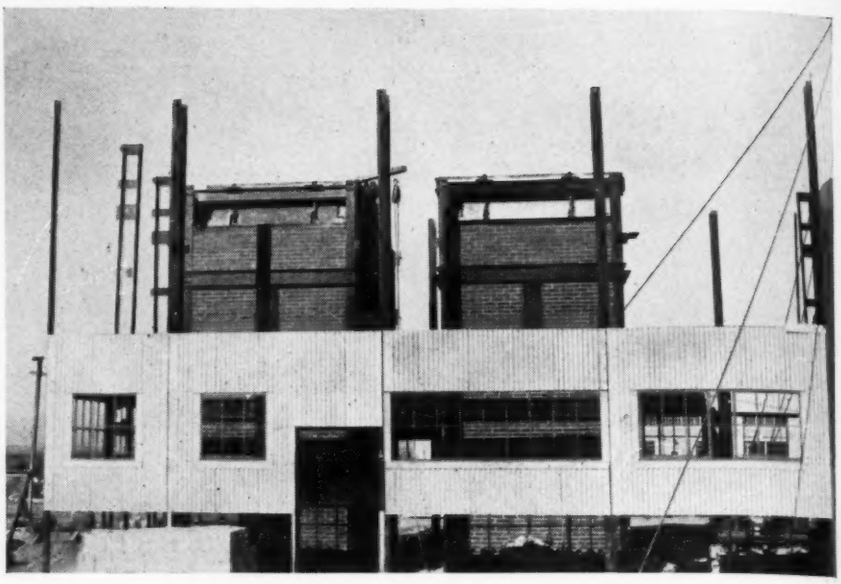


Erection of boiler house for gasoline plant, Liberal station

locate an adequate supply. Six and one-half miles of 6-in. welded water line was laid from the latter station to three wells dug in the Cottonwood River Valley. Water is pumped into a 5,000,000-gal. earthen reservoir at the plant, gas engines being used to operate the turbine pumps. These wells are 28 ft. deep, dug through gravel to shale, and produce about 100 gal. per min. each. Wells at other stations vary considerably in depth, the deepest being at Centralia Station at the 1307-ft. level. A total of 15 water wells were completed at the new stations.

While water for drinking and domestic purposes is provided from the same wells, a separate piping and storage system is necessary to provide untreated water. Piped directly from the main 6-in. supply line from the wells, water is stored in a reinforced concrete cistern 6 ft. by 6 ft. by 6 ft. The delivery of water to the cistern is controlled manually, the operator being guided by a projecting rod-type gauge connected to a float. An American-Marsh Turbo-Lift water system pumps the water from the cistern to a 30-ft. by 30-ft. tank, from which it is delivered under a pressure ranging from 20 to 40 pounds.

Air-cooled engine exhausts and mufflers, installed at all stations, are provided with air-regulating devices, blowers, and, in the "dust bowl" area, air-washing equipment designed to heat the compressor room in the winter and provide washed, cooled air during dust storms and extremely hot weather. This combination equipment employs the jet principle to induce air through a duct surrounding the exhaust pipe, except when blowers are being used to return the air to the compressor room. The air enters the open end of the duct near the exhaust stool of the engine and, contacting the exhaust pipe for its full length, finally merges with the exhaust gases. This flow of air from the basement cools the exhaust pipe and at the same time lowers the temperature of the air in the basement.

During the last two years stations in the "dust bowl" have been subjected to extremely severe operating conditions during dust storm periods. Tons of fine dust entering the compressor rooms have caused excessive wear to moving parts of the heavy machinery and imposed a severe burden on operators. It is hoped that this condition will be greatly improved, if not entirely eliminated, by the use of this equipment. Air, washed by water spray, will be forced into the compressor room through ducts entering above the heads of the operators. Each engine in this area is equipped with a 3-hp. motor and blower capable of delivering 10,000 cu. ft. of washed air per minute. It is expected that a positive pressure of about ½ in. of water column can be sustained in the building. Other stations not equipped with air washers have blowers with a capacity of 4000 cu. ft., driven by 1½-hp. motors.

Although it is expected that compressor buildings will be heated entirely by waste heat from engine exhausts, provided a sufficient number of engines are operating, conventional heating equipment has been provided for use during standby periods. American Blower Corporation floor-type steam unit heaters are installed in the main building, and the auxiliary building. In the meter and regulator house suspended heaters are used. Units are thermostatically controlled. Condensate is returned to the welded steel heating boilers by condensation pumps equipped with complete automatic controls.

Absorption Gasoline Plant and Gas-Dehydration Unit

A noteworthy feature of the absorption gasoline plant and gas-dehydration unit constructed by Stearns-Roger Manufacturing Company at the Liberal station is the new type dehydration system designed as an integral part of the plant. Wet gas direct from the compressor station cooling coils is dried in the absorbers, concentrated calcium chloride brine being used as the dehydrating agent.

The top section of the absorbers is equipped with bubble cap plates and special scrubbers designed to dehydrate the gas to the required dew-point by a

Mississippi River crossing—east end of two 12-in. river lines arched over levee, showing 20-in. header

Mississippi River crossing — view of east 20-in. header and gates

counterflow contact with the brine. A mist extractor is installed above the brine contact plates in order to remove from the gas all traces of the brine. The specially-designed combination absorbers are thus used to extract the gasoline vapor, scrub, dehydrate, and again scrub the gas before delivering it to the transmission line.

Mechanical cooling of the brine, in addition to the atmospheric cooling, is necessary to reduce its temperature to that required in the contactors. Butane is used as the refrigerating agent to reduce this temperature approximately 15 deg. fahr. below that attained in the atmospheric cooling sections. Brine circulating pumps keep the brine moving through the contactors, atmospheric cooling sections, and brine chiller, the flow of brine from the base of the contactors in the absorbers being controlled by float-operated level controllers.

An automatically-controlled steam-heated evaporator removes the water content from the brine after dissolved fixed gases have been vented to the air through a gas vent column. The small stream of brine to the evaporator is controlled by hand from the main circulating system. A part of this side stream of brine flows by gravity to a gravitometer, where any variation of the concentration of the brine causes the movement of a float control that partially opens or closes the evaporator control valve. This action in turn controls the concentration of the brine. Pumps are used to return the brine to the main system.

The absorption plant, designed for handling 135-150 million cu. ft. of gas per 24 hours, will produce any desired grade of finished gasoline from "26-70" grade down to a completely debutanized product.

The four welded steel main absorbers, designed for a maximum working pressure of 500 lb. per sq. in. gauge, are 69 in. O. D. by 57 ft. 6 in. net shell height, with a wall thickness of 1½ inch. Two Erie City boilers, each rated at 250 hp. at 200-lb. steam working pressure, are installed. Two twin Cooper-Bessemer type 80 horizontal compressor units are provided to handle vent vapors from the absorption and distillation cycle. Gasoline storage facilities are provided and shipments will be made from a 10-car loading rack on the Chicago, Rock Island and Pacific Railroad, approximately three-quarters of a mile from the plant.

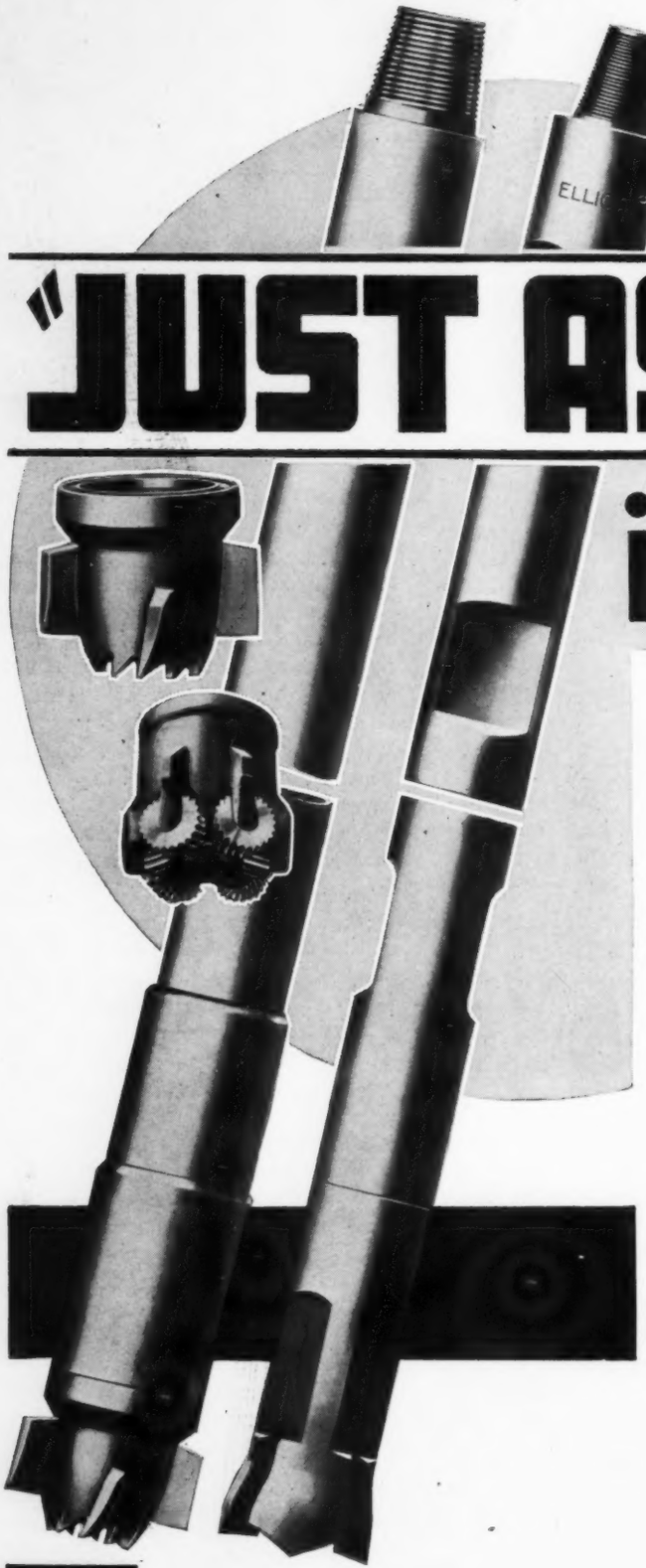
Mississippi River Crossing

The submerged crossing of the Mississippi River, near Louisiana, Missouri, consists of two 12¾-in. O.D. river pipe lines, each approximately 4800 ft. long, two 20-in. headers, and a single land line of approximately 3100 ft. of 20-in. and 22-in. O.D. line pipe. All 12¾-in. O.D. seamless pipe, weight 49.56 lb. per ft., was purchased in double random lengths and field welded with electric arc, using chill rings. Welds were reinforced with welding sleeves, and river clamps placed over all welds and at intermediate points where required. All 20-in. and 22-in. pipe was electrically welded in sections 80 ft. long, using chill rings. Couplings were used to join the 80-ft. sections. The 20-in. and 22-in. lines are installed outside the flood area and do not constitute parallel lines.

Arched sharply upstream where installed in the channel of the river, each of the twin river lines is approximately 450 ft. longer between headers than the calculated base line distance between the same points. The government engineers' "project channel" at this point is 1200 ft. wide. The maximum depth of the channel below low-water elevation of 1864 ft. is 16.7 feet. The War Department requires that the lines be placed not less than nine ft. below this low water elevation.

With the river at a new low stage in August, the contractor varied the usual construction procedure by pulling the 12-in. lines into position from a large sandbar on the east side of the channel. Strung on an elevated sand runway, in line with the final position in the channel, each line was pulled across the river by two Northwest cranes placed on either side of the pipe and connected with the lead line on a set of blocks. Each line was pulled into place in slightly more than 15 hours. Fremont heavy-duty pumps were used to dredge the lines into place. This work was carried on from two barges, although in the deep water where the trench was comparatively shallow only one barge was required. In shallow water, and in the sandbar east of the channel, two barges were necessary to prevent excessive bending of the pipe as it was lowered into the ditch and to keep the deep trench open until the pipe was in place. The work was done by Smith Brothers Construction Corporation, Kansas City, Missouri.

Office building at Sneed station



"JUST AS GOOD" is a fallacy

Hell is paved with good intentions, and similarly, markets always are glutted with products that are "just as good as" or "better than" some similar product of well known merit. Rarely is there any justification for such commendation—never when the product is used in a hazardous service.

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ROTARY AND CABLE TOOL CORE DRILLS

Automatic Control of Distribution Pressure

Long-distance pressure controller automatically maintains adequate pressure at selected point in distribution system and insures economical operation, dependable service, safety, improved processing conditions, and more accurate measurement

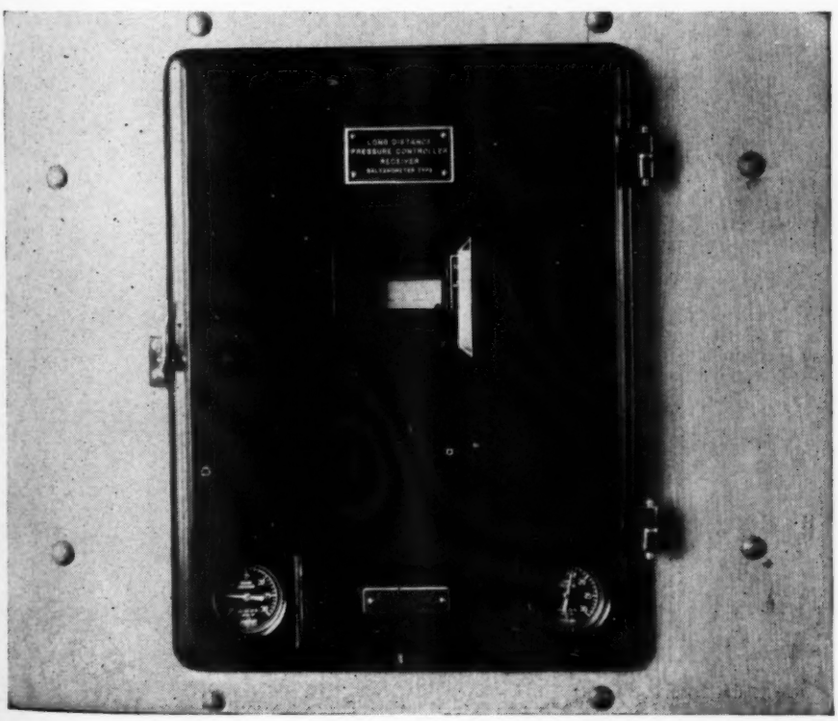
By

ROY W. PARKER

Oklahoma Natural Gas Company

Fig. 1. The Stabilog or transmitter, situated at Walker and Third Streets

ACCURACY and control of pressure to maintain adequate pressure in city plant distribution systems is receiving ever-increasing attention in the gas industry. The objects of accurate control are varied, and include such factors as economical operation, dependable service, safety, improved processing conditions, and more accurate measurement. Though the controls will function mechanically it is desirable that they be automatic in order best to serve the intended purposes.



With that in mind the operating department of the Oklahoma Natural Gas Company decided to install an automatic demand control in the Oklahoma City distribution system. It was put in operation in December, 1935. This installation was the second such long-distance controller in the United States, the original is in Pine Bluff, Arkansas, where many of the details of operation were perfected.

The necessary general mechanical requirements and theory of the control operation, when using the manually-operated "loading type" regulator, is well known to gas men. Satisfactory results may be obtained, but new devices and improvements in the design of instruments appear from time to time to aid the plant operator in his efforts to obtain better regulation. The justification of their use seems evident if they are able to vary automatically the inlet pressure according to load

Fig. 2. The galvanometer or receiving instrument

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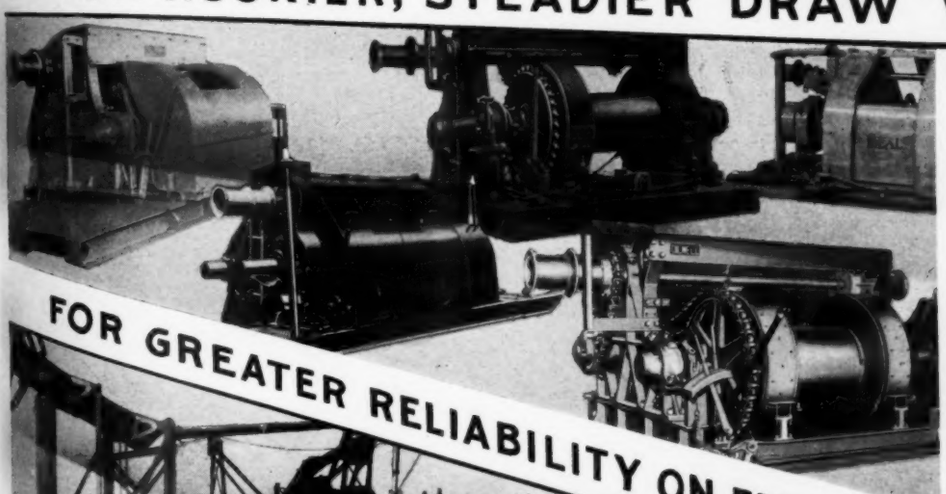

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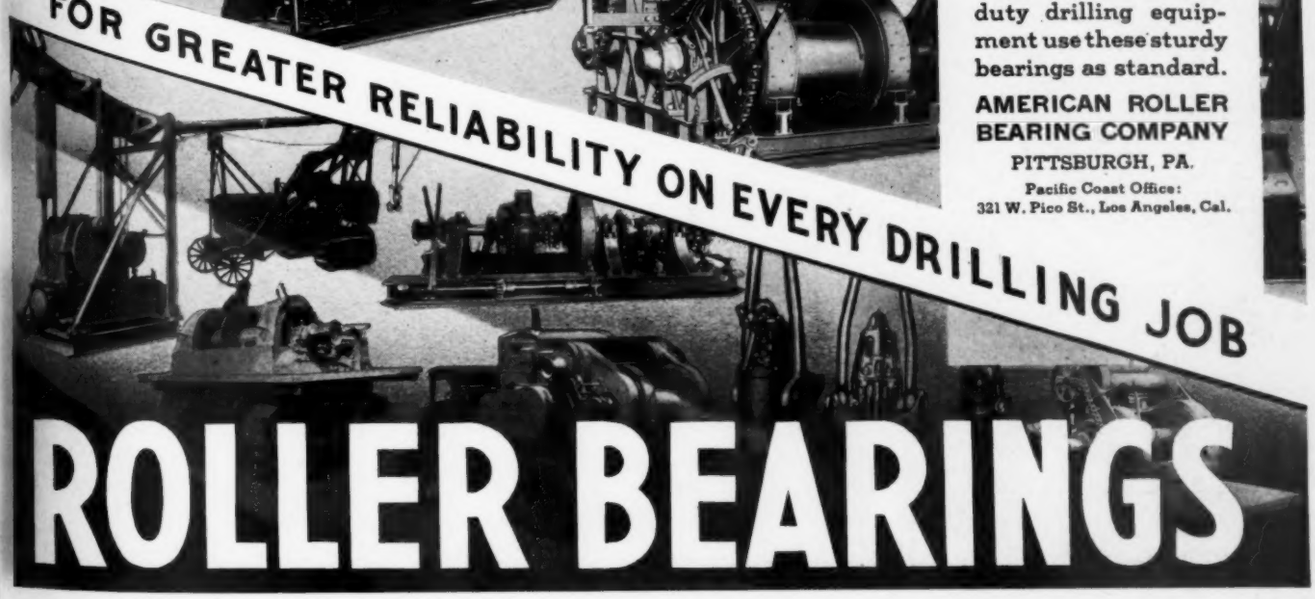

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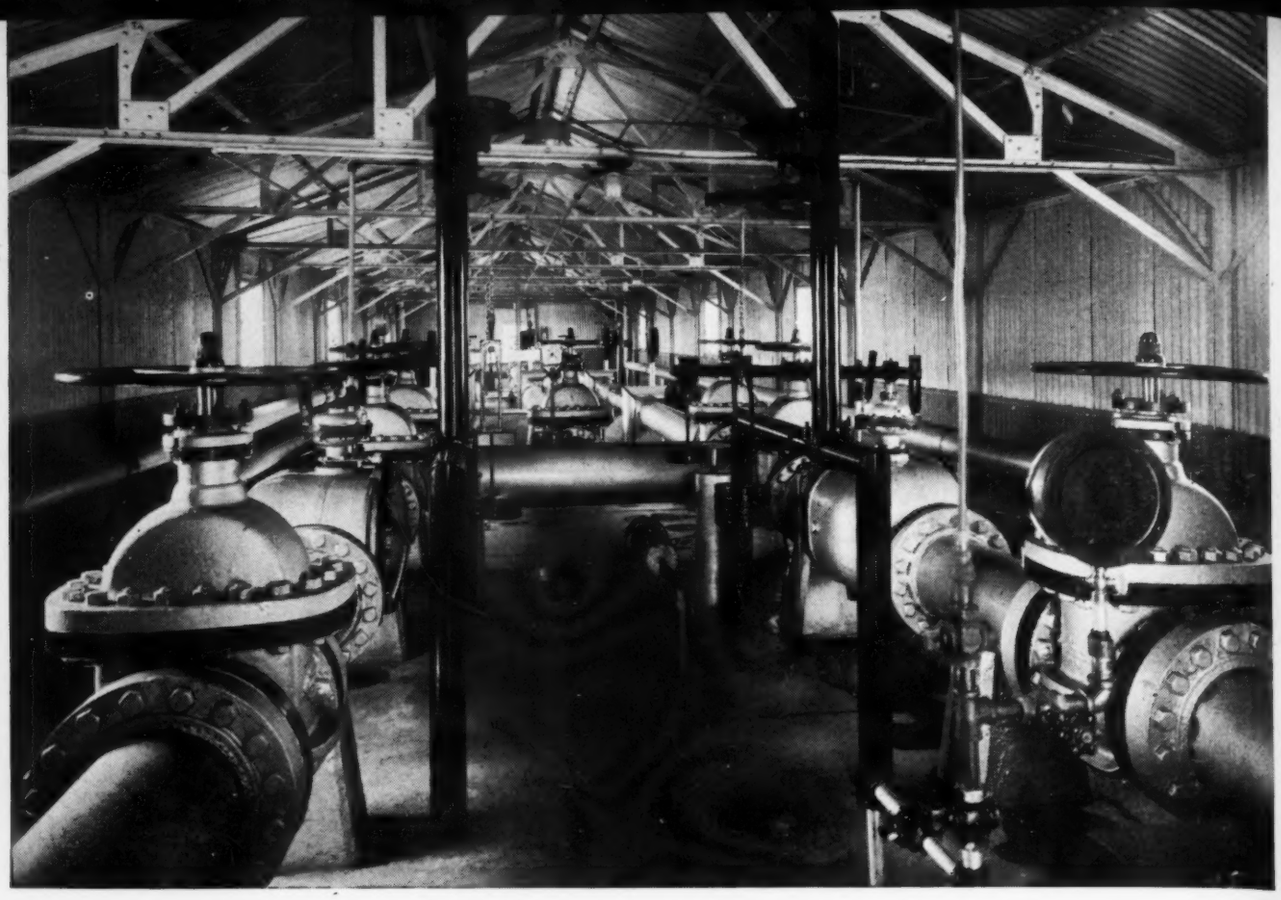


Fig. 3. Oklahoma City North Border Station showing the inlet pressure mechanism in the foreground. The diaphragm motor levers are shown attached to the regulators

and keep the pressure at the selected point constant. The long-distance pressure controller shown in an accompanying illustration and installed in the company's Oklahoma City North Station has recorded very satisfactory operating conditions as indicated by representative charts.

A brief description of this automatic demand control device follows:

Fig. 1 is a Foxboro Pressure Stabilog with a diaphragm motor lever operating a Wheatstone Bridge. It is the transmitter and is placed at a critical point approximately three miles from the border station. Telephone wires connect the two locations. The resistance on either side of the Wheatstone

Chart 1. Pressure record at the critical point before the control was installed

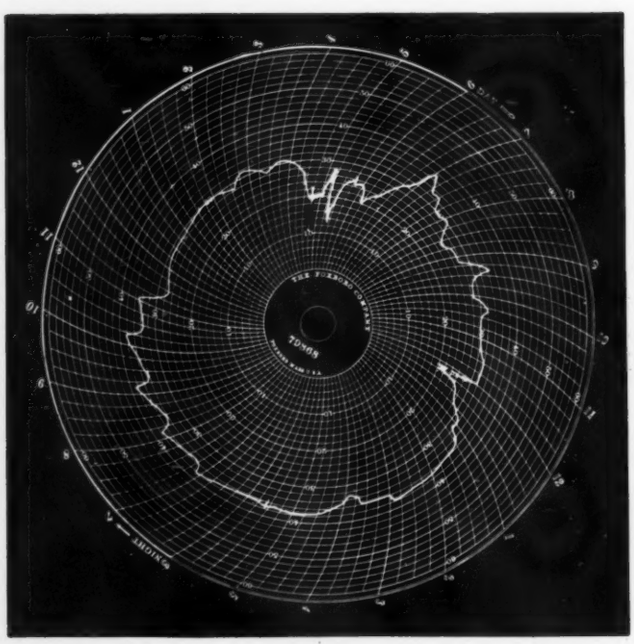
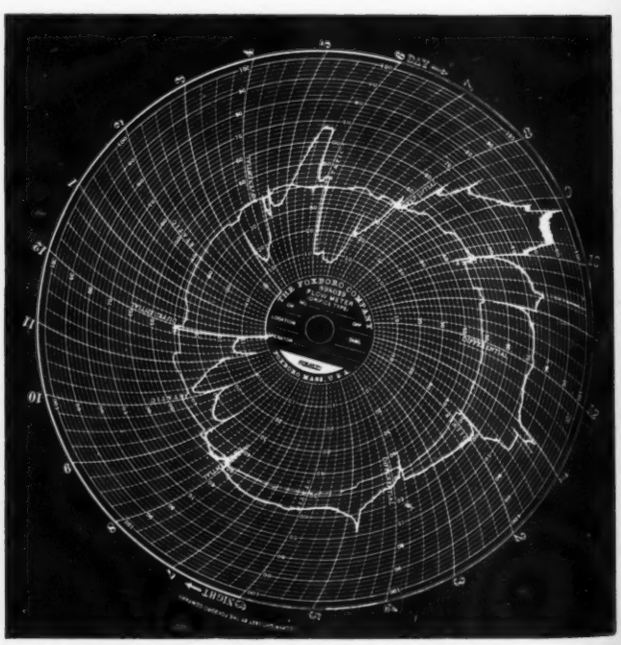


Chart 2. City border orifice meter record before automatic control was started



'STARCOR' SAVES THE DAY

Provides Safety Factor When Plug-Manifold Leak Holds Up Cementing

IT WAS 200 degrees, 6018 feet down (7" O. D. pipe in 9⅞" hole), in United Gas Company's Stewart No. 3 at Rodessa. Gauge on mud pumps showed 900 lbs., as 10.2 mud was circulated from 4:50 to 5:20 a. m., August 21st.

At 5:25 a. m., 'Starcor' started down the hole. Slurry weights, from 15.4 lbs. to 16.6 lbs., averaged 16.2 lbs. per gal. Thirty minutes later, plug was released and mud pumps started.

Delays Often Happen

Then the unforeseen happened—"one of those things" that so often hold up cementing, in spite of every possible precaution. A plug-manifold union leak developed when the cement was almost all in position. Pumps were stopped and the connection tightened. When the pumps were restarted and the plug finally seated on the collar, pump pressure was only 1050 lbs.

Built-in Safety Factor

There are two ways to avoid stiff slurry in hot holes: One is to use excess water, which means reduced density and decreased strength—the other is to use 'Starcor', the Oil Man's cement with the built-in safety factor against quick-setting.

'Starcor' is specially made for use in deep, hot holes and for resisting mud contamination and sulphate-water action.

'Starcor' sets slowly, even in the hottest holes. But note how quickly it hardens: On August 24th, when plug on this job was drilled out, they found a dense, hard, uniform core—and chemical analysis of cuttings showed complete freedom from mud contamination.

Use 'Starcor' Next Time

'Starcor' is a Portland Cement, specially made for oil men. No adulterants are used, no admixtures are needed. 'Starcor' has all the valued properties of 'Incor' and Lone Star—plus the special qualities needed for deep-hole work. Use 'Starcor'† on your next job—see what a real Oil Man's cement is like. Any Lone Star and 'Incor'* Dealer can supply you, pronto. Lone Star Cement Corporation, Dallas . . . Houston.

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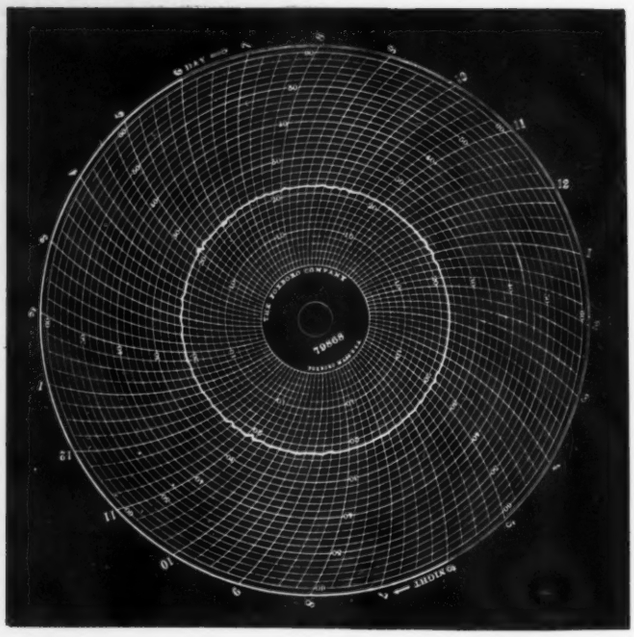


Chart 3. Record of pressure at Walker and Third Streets, controlled automatically

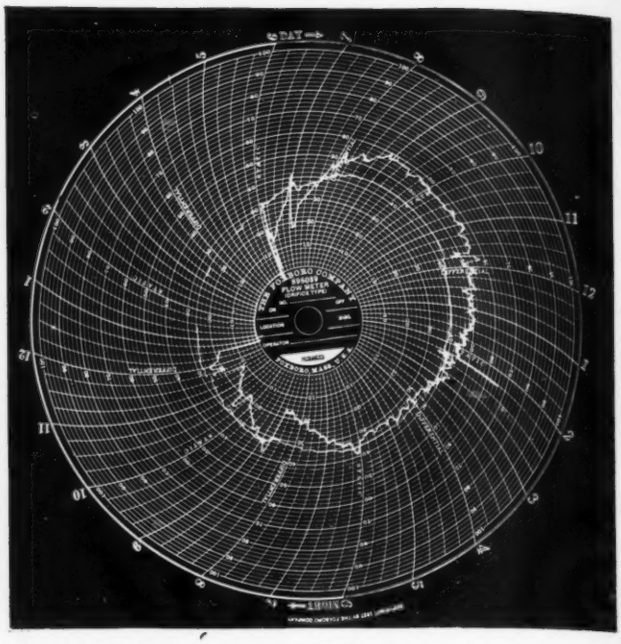


Chart 4. Orifice meter record of city border delivery and pressure after control was installed

Bridge is varied by the Stabilog according to the gas consumption or draw-off at that time. This variation in resistance is instantly transmitted to the receiver or galvanometer, Fig. 2, and causes a deflection in this receiving relay. The controlling mechanism, Fig. 3, is so designed that the impulse received by this galvanometer and relayed to the actuating valve, is proportional to the actuating force at the transmitter or critical point, and therefore keeps the system in balance at all times. These two pressures need not be the same, as calibration of the two instruments will maintain a proportional deflection. This permits the use of a pilot pressure as low as five lb. at the demand end and still maintain a pilot pressure of 15 lb. at the point of regulation. This permits the use of line gas. The essentials of this system of control are, first, a throttling range that can be adjusted to suit unfavorable lags and, second, a follow-up mechanism that prevents change of control point.

Safety features are incorporated in the system that automatically will take care of current failures or operating pressure difficulties.

The distribution system in Oklahoma City presents the normal operating difficulties characteristic of a plant of that age. There is a rather variable load demand on the system caused by the several large and small industrial consumers in the downtown area. The exact requirements come without warning and manual pressure control on a predetermined schedule is difficult.

The accompanying charts serve to illustrate the operation before and after this control was installed. These charts were made in January, 1936.

Chart No. 1 is a 24-hour record of the pressures at the demand point, Third and Walker Streets, before the control was installed. It can be noted that the pressure was carried unnecessarily high most of the time to assure a safe pressure during a peak load. The pressure varied from 14 lb. to 39 lb. during this period with an average pressure of about 32 pounds. This pressure fluctuation caused by sudden demands is not desirable for proper low-pressure distribution where it may cause poor operation of appliances and equipment.

Chart No. 2 is an orifice meter record from one of the meters at the North Station or inlet of the intermediate system before the automatic equipment was put in operation. This record shows a fairly steady pressure of about 48 lb. for the period from 9 a.-m. to 9 p. m. The demand indicates that such pressure was necessary. Several cuts were made during the following three hours until flow ceased through this run at midnight. The pressure during the minimum flow period is about 37 lb., considerably higher than necessary.

Chart No. 3 shows the pressure at the demand point after the controller was cut in. It is noted that this pressure is 22 lb., without an appreciable variation during the entire 24-hr. cold period. The pressure this summer was held at ten lb., whereas, in preceding years the summer average was about 25 pounds.

Chart No. 4 shows the differential and static record during a 24-hr. period of automatic control. It can be observed that the two lines go up and down together, producing a greater effective range at the orifice meter. This is desirable, as the record for low flows will be more readable and the differential will not be forced to go so high to represent the same peak volume. The period of no-flow shows a pressure of 26 lb., a reduction of 11 lb. as compared with Chart No. 4.

An inspection of the four charts, supplemented by favorable comments on service, is evidence that the objectives sought when this control was installed have been realized. The plant is operated more economically because of reduced leakage and labor overhead; service is more dependable; unvarying pressure to consumers permits improvement to processing conditions by better established gas utilization; the possibility of line ruptures or failures are lessened with lower pressures, which promotes safety; and more accurate measurement is assured when records are obtained that are more readable.

Lining Oil Reservoirs in Wells With Concrete

By F. R. COZZENS*

Modern practice in old fields employs concrete for multifarious uses in oil fields of Ohio, West Virginia, and Kentucky

IN the oil-producing sections of Ohio, West Virginia, and Kentucky, concrete is being used 2000 ft. underground in the construction of reservoirs in newly-drilled wells. When this territory was first drilled (1900-1925) the general procedure of operators was to shoot the well with as much nitroglycerin as the sand-face would carry, the usual formula being two quarts of explosive to each foot of sand. The idea was that the more the rock was crumbled, the greater would be the capacity of the well for holding fluid. This theory, though partly correct in principle, did untold damage because shales always underlie the oil-rock, or producing stratum. These shales are loose and porous, and it was soon discovered that for every barrel of oil pumped out an equal or greater amount was seeping through the underlying shales. In hundreds of cases this seepage has been sufficient to ruin a well. When such seepage occurs the only known effective remedy is to plug-off the sand and redrill the location.

Operators today take no chances with trouble from seepage. With a series of well-timed explosive shots a reservoir of the desired shape and capacity is made at the bottom of the hole. A permanent leak-proof floor is then made by using a proper mixture of concrete. This provides a foundation upon which future developments are carried out.

The process begins when the drill first reaches the oil-rock. At this point, the hole is reduced in diameter. A smaller drill is then used to penetrate the oil-rock and drill through it into the shales to a depth of two feet. The sand is then given a priming shot, usually consisting of five quarts of nitroglycerin, or eight cartridges of gelatin-dynamite of 60 percent strength. The hole is then cleaned-out by suction bailer, and the shooting repeated until a chamber of the desired size is made in the sand. Measurement of the capacity of the chamber in bottom of hole is made by pumping salt-water down the hole until the chamber is filled. This water is then bailed out or pumped out, and the amount of water required to fill the hole determines the size of the chamber. The size and capacity of the underground chamber is based entirely upon the thickness of the sand. A well having a sand-thickness of 20 ft. should have a chamber of 100-bbl. to 150-bbl. capacity. The greater the volume of sand, the larger the chamber. After an initial shot, the chamber may be found to hold from ten to 20 bbl. of water. A second shot increases the size. Subsequent shots are placed until the desired capacity is reached. Salt-water usually is used for measuring capacity, because it is commonly found in all oilfields, and can be piped into a well at very little cost. Then again, salt-water, unlike fresh water, is not injurious to oil-sands. In fields where salt-water is not available, crude oil is often used. The crude oil is pumped from the well back into the storage tanks. In newly drilled wells with plenty of natural rock pressure, the capacity of the chamber in the hole can be judged roughly by allowing the well to stand until it "heads up". The number of barrels pumped out after it heads up will show fairly closely the size of the chamber. After measurements of capacity have been carefully taken the hole is then ready for concrete.

A primary mixture, made up of one part quick-setting cement to two parts white sand, mixed to the consistency of batter, is first introduced by means of a bailer. The bailer has a trip in the bottom so that its contents are released when it reaches the bottom of the drill-hole in the shales. The bailer is re-filled and lowered until the concrete has reached a depth or thickness of six inches. After the primary mixture or foundation has firmly set, the process usually requiring six hours, a secondary solution is poured down the casing. This consists of one part quick setting water-cement, to one part sand, mixed to a consistency of ordinary paint. This mixture is poured in until an additional six inches has been added to the foundation coat. The average well requires three barrels of primary mixture, and one barrel of secondary solution. The average cost including labor is less than $30 per well, and one treatment is sufficient for a permanent job.

The average life of an oil-well is from ten to 25 years and when its period of production has ended, concrete plays another very important part. Abandoned wells must be sealed, and the seal must be both air-tight and water-tight. State laws require it, and the modern operator takes no chances on a mud seal that may admit sufficient fresh water to ruin the entire oil-producing area. After all casing and pipe have been removed, a tapered wood plug is driven down the hole to a point about ten ft. above the oil rock. A mixture made up of one part ordinary building cement to two parts clean white sand, mixed to the consistency of paste is then poured down on top of the plug. In the average 6-in. hole, ten gallons are sufficient to provide a permanent seal, answering all requirements of mining laws.

In the re-drilling of old fields, a practice that is being carried out in various districts, concrete replaces more than a score of old-time substitutes. In sealing crevices in drilling wells, concrete replaces ruble rock, cinders, and lime. It replaces wood in foundation construction. Stud-bolts are anchored in concrete. Power and pumping houses have concrete floors, and tank-bottoms are generally of concrete construction. In these, and sundry other uses, concrete cuts operating costs, and reduces repair bills by as much as 80 percent. It is oil- and acid-resisting, reduces fire risk, and can be utilized by the average oil-field crew under all operating conditions.

*Equity Oil and Gas Company, Stockport, Ohio.

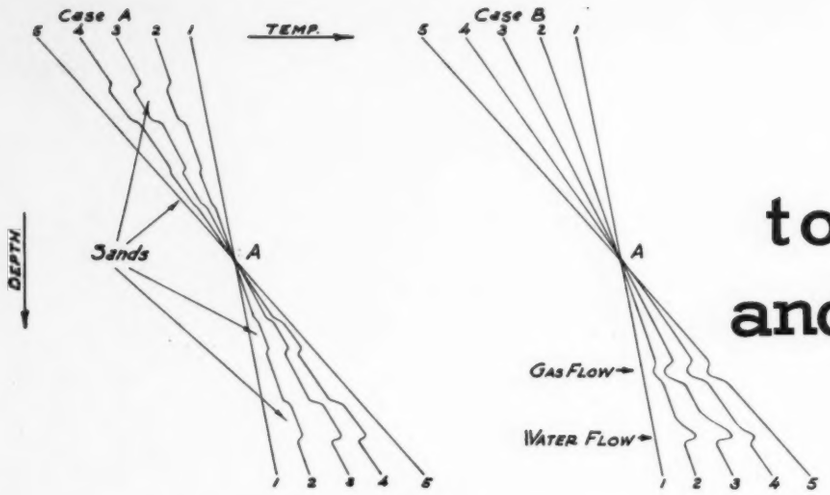


Fig. 1. Diagrammatic illustration of temperature curves

Electrical Technique to Petroleum and Engineering

By
L. W. STORM* and
R. T. WADE*

THE applications of Schlumberger service that interest the oil operator and the petroleum engineer particularly arise in connection with the following operations.

(1) The completion of wells.
(2) Reconditioning wells to shut off water.
(3) Reconditioning wells to exclude gas.
(4) Evaluating the sands, calculating reserves, estimating potentials, and other similar problems.
(5) Various operations, such as checking casing depth, locating junk in a well, ascertaining distribution of cement behind casing, etc.

The uses of the surveys and diagrams for working out structure and sedimentary changes, by the geologist, are not described here. These uses, which might be called the geological aspect of Schlumberger service, are extensive and various, but there is not space for their treatment in this article.

Schlumberger equipment and technique have been described in a number of publications, a list of which is given for reference at the end of this article.

In addition to the regular equipment for resistivity and porosity surveys, temperature surveys are now used in conjunction therewith. They also have been previously described, so that for present purposes a mere outline description of each method may be sufficient.

The regular survey provides the now quite familiar resistivity and porosity diagrams. These are obtained by lowering electrodes into the well at the end of an insulated cable.

The specific resistivities of all formations that the well has penetrated are obtained by passing current into the ground from a battery and measuring the potential thus set up between two closely-spaced electrodes as these

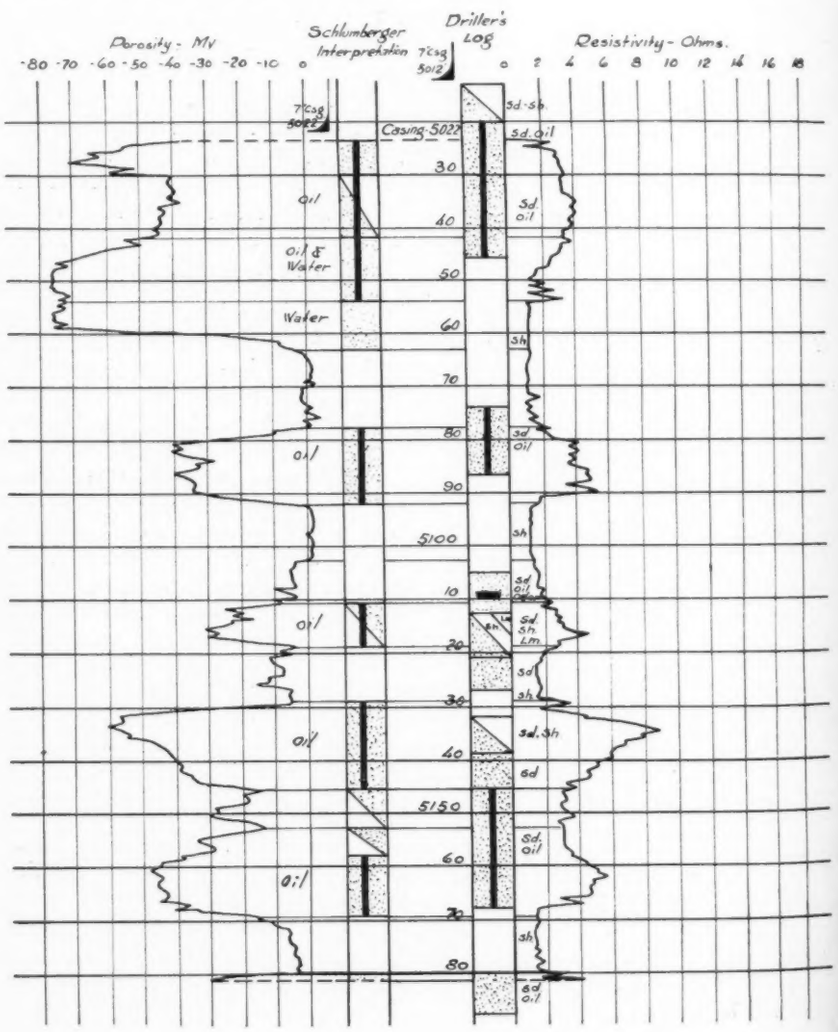


Fig. 2. Well at Barber's Hill

*Schlumberger Well Surveying Corporation.

Logging as Applied Production Problems

Aside from its value in geologic studies, electrical logging today plays an important role in petroleum production and engineering practice. Though based on scientific principles, electrical logging is finding many and varied applications to the solution of practical field problems encountered in everyday drilling and producing operations. The more important of such applications are outlined in this article, which was prepared specially for THE PETROLEUM ENGINEER.

are drawn up out of the well. The porosity diagram—*an entirely independent curve*—records the electrical effect of physical and chemical reactions that accompany the interchange of fluid between the mud in the hole and the porous formations with which it comes in contact. Each of these two curves, recorded simultaneously, is a continuous record or log of the electrical property that it measures, and taken together they supplement each other to form a better record than either one does alone. These measurements, moreover, are recorded and plotted to scale at the well—so many inches of record per hundred feet of hole surveyed.

The temperature survey also provides a continuous record, which may be compared directly with the resistivity and porosity diagrams. This record is obtained by lowering into the well at the end of the insulated cable a very sensitive electrical thermometer, which records the temperature to scale on the surface.

In making a temperature survey the usual procedure is, first, to circulate the mud content of the well until its temperature is as nearly as possible the same throughout. In practice this cannot be fully accomplished but after circulation for an hour or more the mud temperature in all parts of the well is approximately equal to the average temperature of the formations traversed, or, roughly, that of the formations halfway down the well.

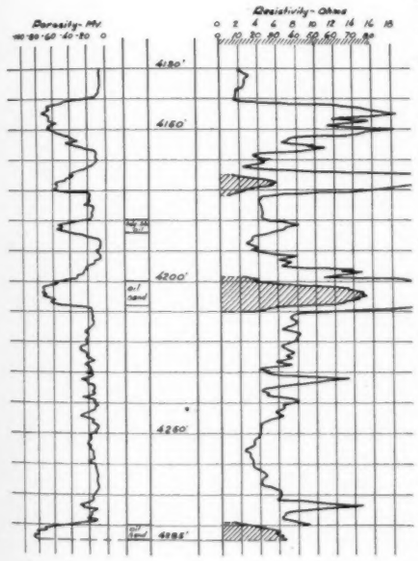
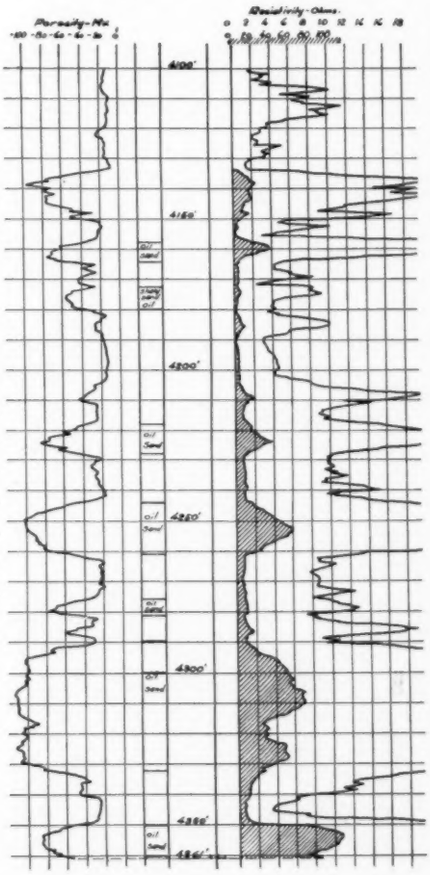


Fig. 4. Two wells in Talco area of Texas



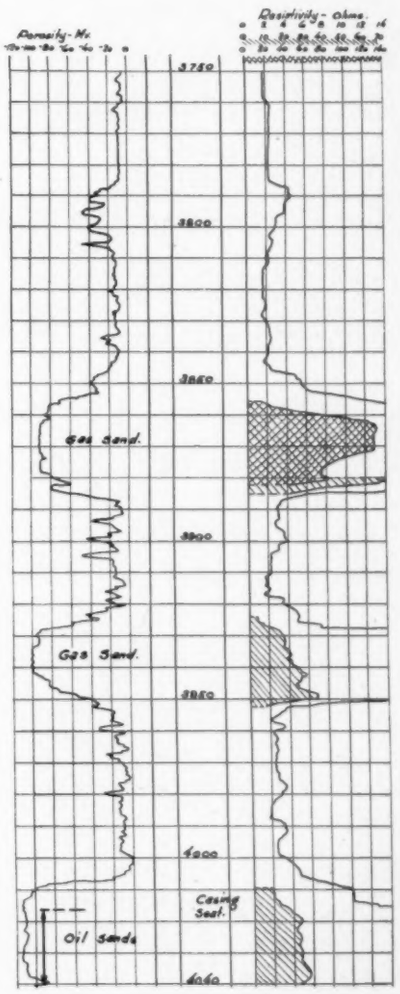


Fig. 3. Well at Cayuga

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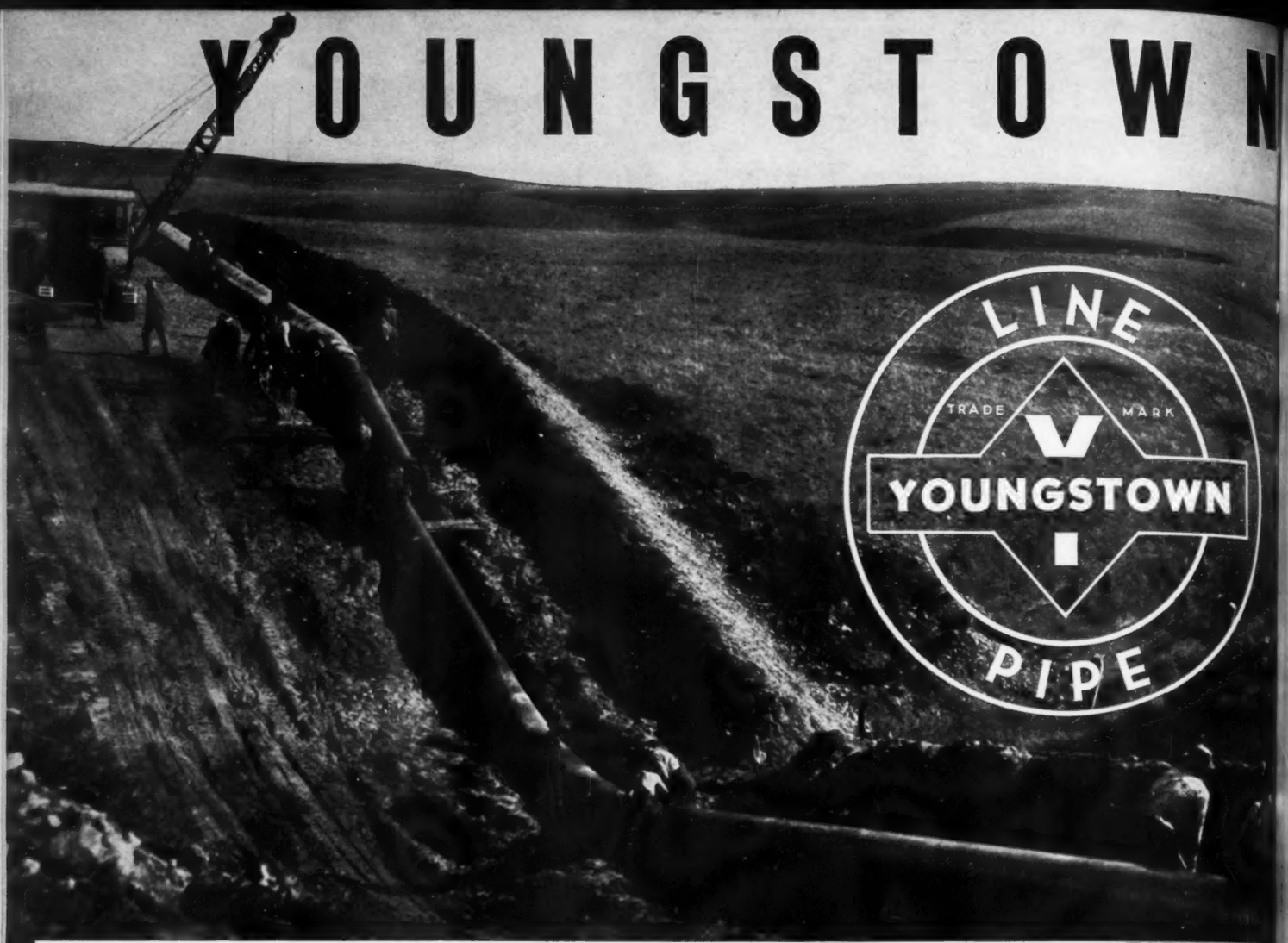

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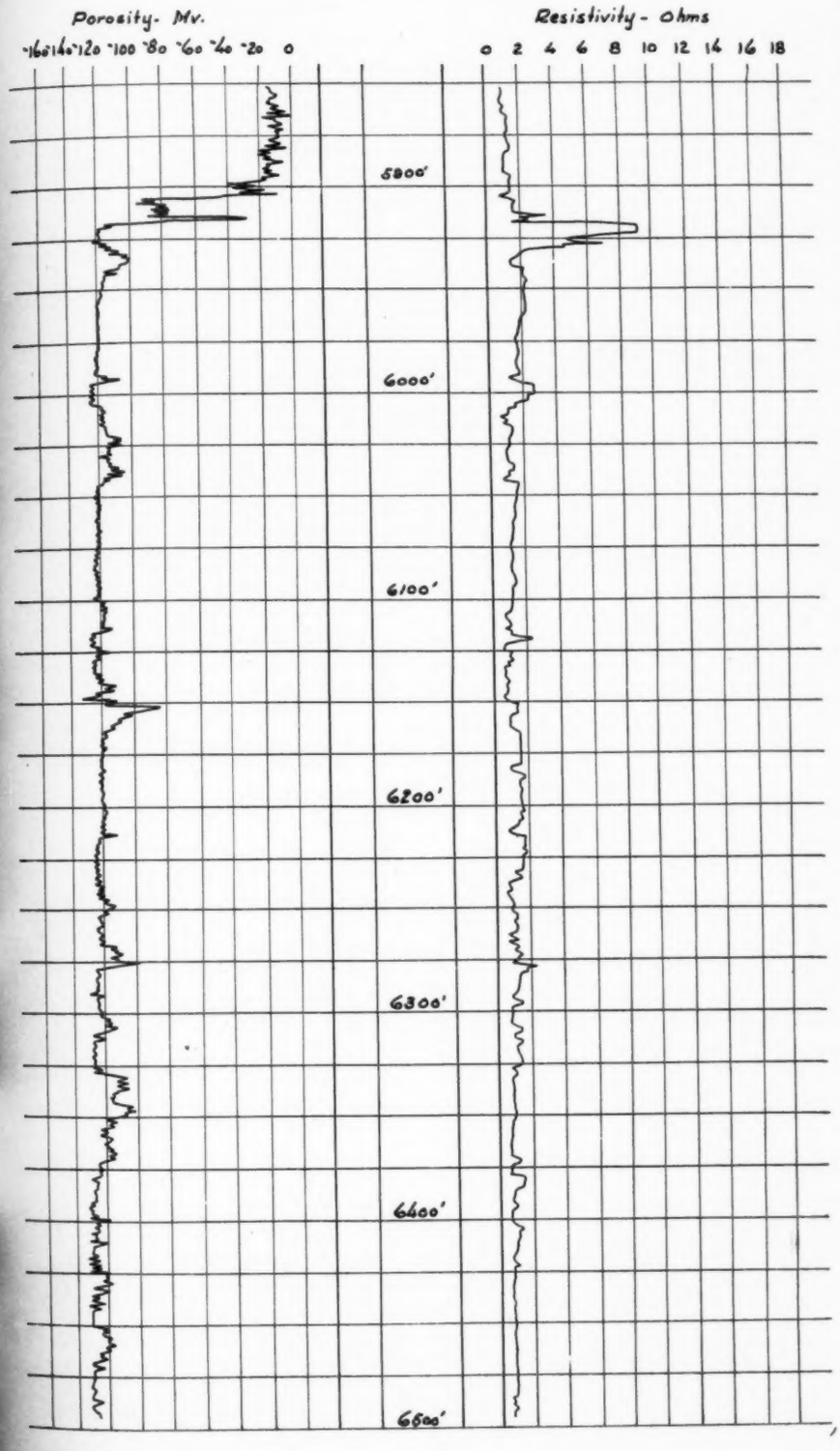
Hot or cold temperature (weather) at surface, affects this average temperature considerably. All that remains, then, is to allow the mud temperature to conform gradually to the normal temperature gradient from top to bottom of the hole, making surveys from time to time to note changes. A survey made immediately after stopping circulation will show a slight departure from uniform temperature, as curve 1 in the illustration, Fig. 1, theoretically illustrates; and a survey made several weeks later with no circulation between will approximate the normal gradient curve showing breaks, usually slight, at formation contacts (see curve 5). It might be supposed that surveys at intermediate times would show only a gradual change from the one form of curve to the other, but such is generally not the case. Sands, and particularly water sands, exchange heat with the mud, warming or cooling it as the case may be, faster than the shales, for example, do. Gas, which has been flowing or which is flowing into the well, will show a cool anomaly due to its expansion. Water entering the well will show a warm anomaly. Cement, by the heat generated in setting, will record its presence around the casing. These anomalies, shown by curves 2, 3, and 4 in the diagram, Fig. 1, generally reach a maximum several hours after circulation ceases and then fade out again in the later curves as the formations that transmit their heat slowly have time to catch up in their effect with the more active heat-transmitting formations. (Note the rotation of these curves about the average point A.) The effects of inflowing gas or water may persist, however, into the later curves. A modification of the method is to induce inflow of water or gas by bailing mud out of the well.



The examples that follow and their discussion are given principally to illustrate results obtained but will serve further to explain the methods themselves. It should be noted that resistivity and porosity surveys can be carried out only in open (uncased) hole, though temperature surveys are applicable also to cased parts of a well.

The headings listed at the beginning of the article can now be taken up in order.

(1) Uses of the Diagrams in Connection with the Completion of a Well

Important points in connection with completing a well are:

Selection of casing seat.

Where to bottom the hole.

Where to set screen, liners, or packers, or where to perforate casing.

Fig. 2, representing an example from Barbers Hill, is a recompletion rather than an original completion, but nevertheless it illustrates several of the points just mentioned.

Comparison of the drillers log, which includes the core record, with the electrical logs reveals:

(a) Casing depths corrected by ten feet. Correctness of the geophysical measurement was verified by later measurements in completing the well.

(b) The diagrams show sand from 5024 ft. to 5063 ft., the bottom 17 ft. carrying water as shown by the low

Fig. 5. Well in South Texas

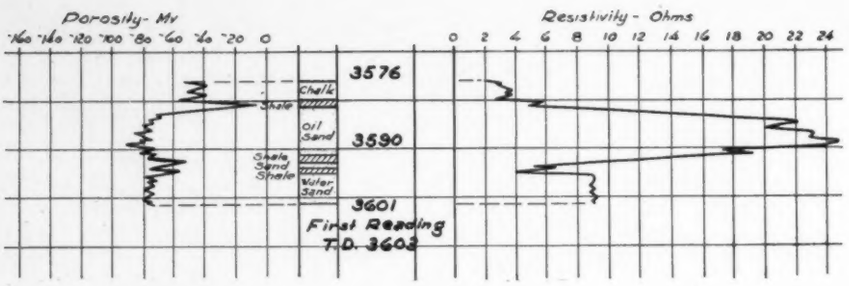


Fig. 6. Plugging back water, East Texas field

resistivity. Well log shows oil-sand and shale with no water. It may be explained that this is a depleted sand, from which nevertheless cores will show a large content of oil and very little indication of water. Mistake after mistake has been made by setting screen in this sand on account of the excellent showing. In this case the electrical record obviated this mistake.

(c) The diagram and the well log agree in showing oil sand from 5078 to 5092 ft.—allowing for discrepancy in measurements—but from 5129 to 5146 ft. the diagram shows oil sand while the well log records shale, sandy shale, and sand with no indication of content. This probably was drilled, not cored.

Again, the well log shows sand with oil from 5146 to 5156 ft. while the electrical log records sand and shale.

In this instance the electrical log helped greatly to clarify the situation.

Casing was set at 5078 ft., cutting off the depleted sand carrying water. Screen was set only opposite the sands 5078 to 5092, 5129 to 5146, and 5158 to 5168 ft., with blank liner between. By knowing the exact positions of the sands, enough wire-wrapped screen was saved in the settings to pay the cost of the survey that resulted in deepening and recompleting this well as a good oil producer free from water.

Fig. 3 is the log of a well at Cayuga.

At Cayuga, as also at Long Lake, the upper part of the Woodbine section contains gas, and a delicate problem is presented of producing oil from an approximately 20-ft. section between the gas and the water.

The practice here is to drill without coring to a few feet above the known gas-oil level. Then core for about 20 ft. to get samples of the oil sands, bottoming the well a few feet above the known water level — approximately subsea 3770. After this an electrical survey is made, the advantages derived from which are:

(a) To locate accurately all markers for correlation, top of Woodbine particularly.

(b) Coring several hundred feet of Woodbine section above the oil is obviated. Yet the positions of all the gas sands there are recorded accurately by the electrical survey, so that it will be possible to perforate casing in the right places to tap them when this becomes necessary.

(c) The geophysical record is a valuable check on the cored record of the oil sands, helping to define accurately the tops and bottoms of the sands, and especially to help in choosing the right casing seat.

(d) As the water level is variable within limits of a few feet, the diagram is useful in checking whether the bottom of the hole is actually dry or not.

Fig. 4 shows a comparison of two wells at Talco.

Electrical surveys are valuable at Talco as elsewhere to define markers and for accurate knowledge of the section penetrated, but they are particularly useful to show positions and thickness of oil sands, these sands showing up with high resistivities.

Though there are quite commonly two main sand horizons in this district, the Carr and the Galt sands, separated by some 60 ft. of mixed red beds and shales, still this arrangement is complicated by one or the other of these sands

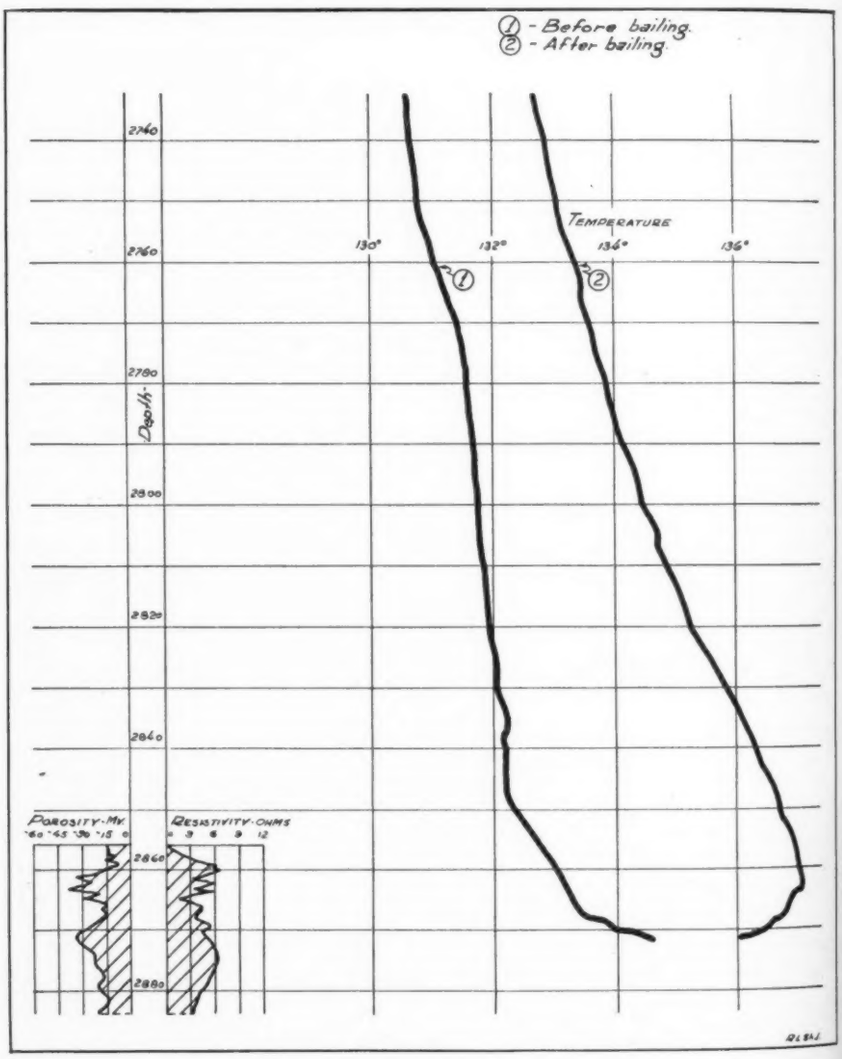


Fig. 7. Location of a water flow, Rogers and Rogers No. 1 Cueller, Hoffman, Texas

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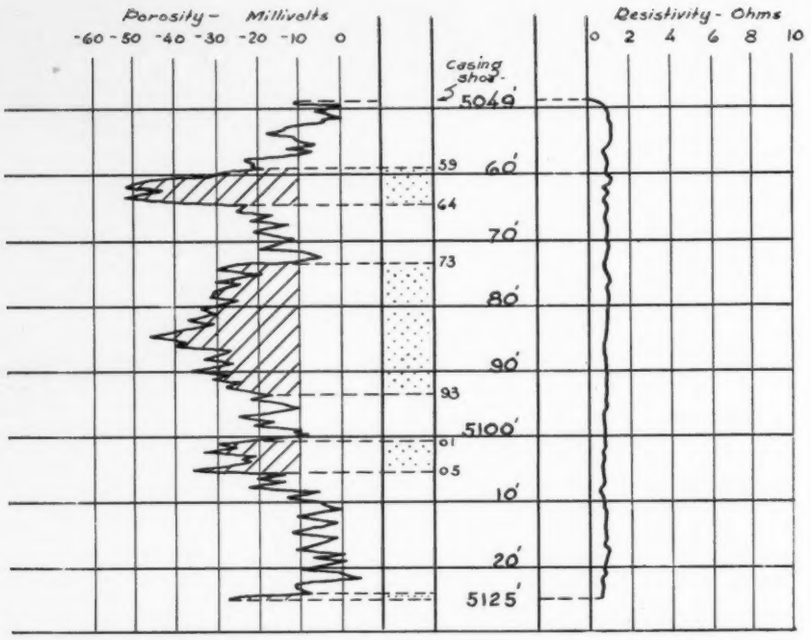

Fig. 8. Well in Conroe field, Texas

becoming shaley and by sands developing in other parts of the section. To get an accurate idea of the sands in a well, by coring, would require continuous coring of a section often as much as 150 ft. thick. The geophysical survey will provide such a record, and at very low cost.

A very valuable use of the electrical work, of which we have no example for publication, is the logging of a series of sands through which casing is afterwards set, with a view to perforating for these sands later on. This may not be for many years later, only after the sands below successively have become depleted of oil and invaded by water. The Cayuga log may serve as an example of such a record for gas sands, but elsewhere, notably in South Texas, there are instances of from three to as many as six sands known to be oil-bearing and held in reserve behind casing while a lower sand—so far, usually the lowest sand in the series—supplies the output of the well. Often such sands actually are found by the electrical method, not having been cored or logged otherwise in any way.

Such a series of sands may be distributed through several hundred or even several thousand feet of section and the advantage, in cost as well as in certainty, of logging them by electrical recording is obvious. In fact, such recording is generally considered indispensable. Greta, Tom O'Connor, Refugio, Placedo, and Saxet are examples among many others of fields where such series of sands exist.

(2) Reconditioning Wells to Shut Off Water

Fig. 5 of a well in South Texas illustrates a full-hole cementing job and perforating for oil above the water.

Some 600 ft. of sand was encountered in the drilling, but as much of this showed signs of water, an electrical survey was made to determine whether any of the sand would produce oil. The survey showed oil only at the very top, the low resistivity below 5930 ft. indicating water. Casing was set and cemented all the way to the bottom and perforations above 5930 ft. resulted in a 1300-bbl. well.

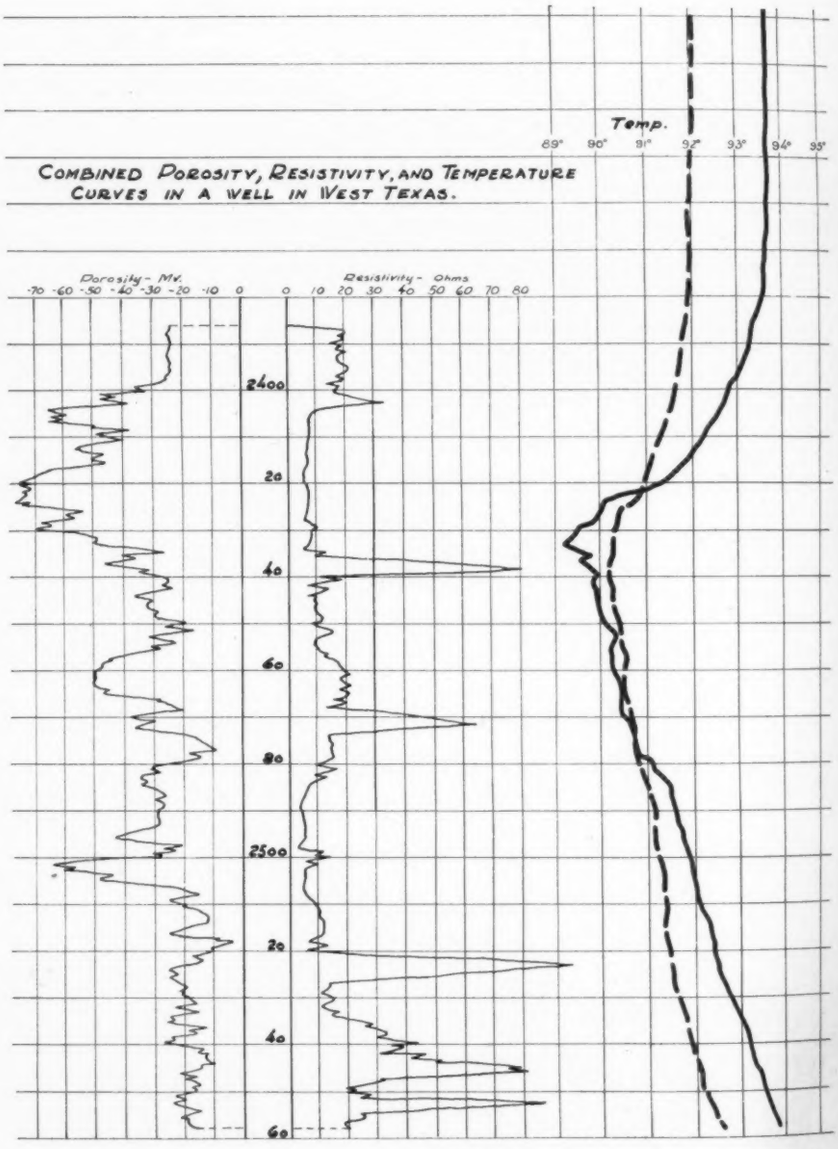

Fig. 9.

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Fig. 6 is an example of a well in East Texas. This well was producing 25 percent water. The survey, by low resistivity, indicated water in the sand below 3595 feet. By plugging back to 3588 ft. the water was cut at once to less than one percent and gradually fell off to practically nothing.

Plugging-back jobs in East Texas, as a result of electrical surveys, are successful in at least 90 percent of the cases. Wells often were finished in a hurry and the sand section cored incompletely or not at all. If the well begins making water, the first necessity is to have an accurate log of the sands. The survey will give this and also will show the level to which water has encroached. All that is needed is to select a good shale break above this level and plug back to it, after which, unless the whole sand section has been contaminated with water by too rapid withdrawal of oil (hot oil sections), there will be no further trouble with water until the general level has risen further.

Often in plugging back without a survey, a first attempt is made without knowledge of shale breaks or hard sands, with the result of a failure. There may be a second and even a third similar attempt, but after a survey one job usually is sufficient.

Fig. 7 is an example of the location of water flow by a temperature survey. In this case mud was bailed out of the well to induce the flow of water. Curve 1 is the record of a temperature survey made before bailing. Water was held out by the mud pressure, and a warm effect, which normally appears at the bottom of a well, was recorded.

By bailing, and so relieving pressure, the water was allowed to flow into the well and is indicated (see Curve 2) by the warm spot at about 2864 feet. Naturally, on account of the general rise of fluid in the well due to bailing, the temperature shown by the whole curve above 2864 ft. is higher than in Curve 1 (average about two degrees), while the temperature at the bottom of the well is only about one degree higher, the shape of the curve being reversed.

Whether coming from a leaky casing seat, from the bottom of the well, or from an intermediate point, the place of water entry usually can be located by one method or the other, electrical or temperature, or by a combination of the two.

(3) Reconditioning Wells to Exclude Gas

Fig. 8 shows a case at Conroe. In this instance there had been for one reason or another a complete failure to get a log of the sand section. The well had been drilled to 5125 ft. (subsea 4970 ft.), or 20 ft. above water level for the field. Casing was set at 5049 ft. (subsea 4894 ft.), or some 40 ft. below the average gas-oil contact for the field. The well was an average oil well to start with, but the gas-oil ratio gradually increased to where, under Railroad Commission orders, its oil production had to be cut to eight bbl. a day, while neighboring wells with a proper gas-oil ratio were permitted to produce between 45 and 50 barrels.

It was proposed to lower casing and tubing, but such information as there was indicated that the producing sands were all just below the casing seat and would be cut off by lowering it. The electrical survey showed sands at 5059 to 5064, 5073 to 5093, and 5101 to 5105 feet. Liner with a packer was set between 5064 and 5073 ft. and screen opposite the lower sands, after which the well was brought in with a normal gas-oil ratio of only 450 cu. ft. per barrel. Potential of the well at ¼-in. choke was 510 bbl., which gave it an allowable of 45.51 bbl.—an average well.

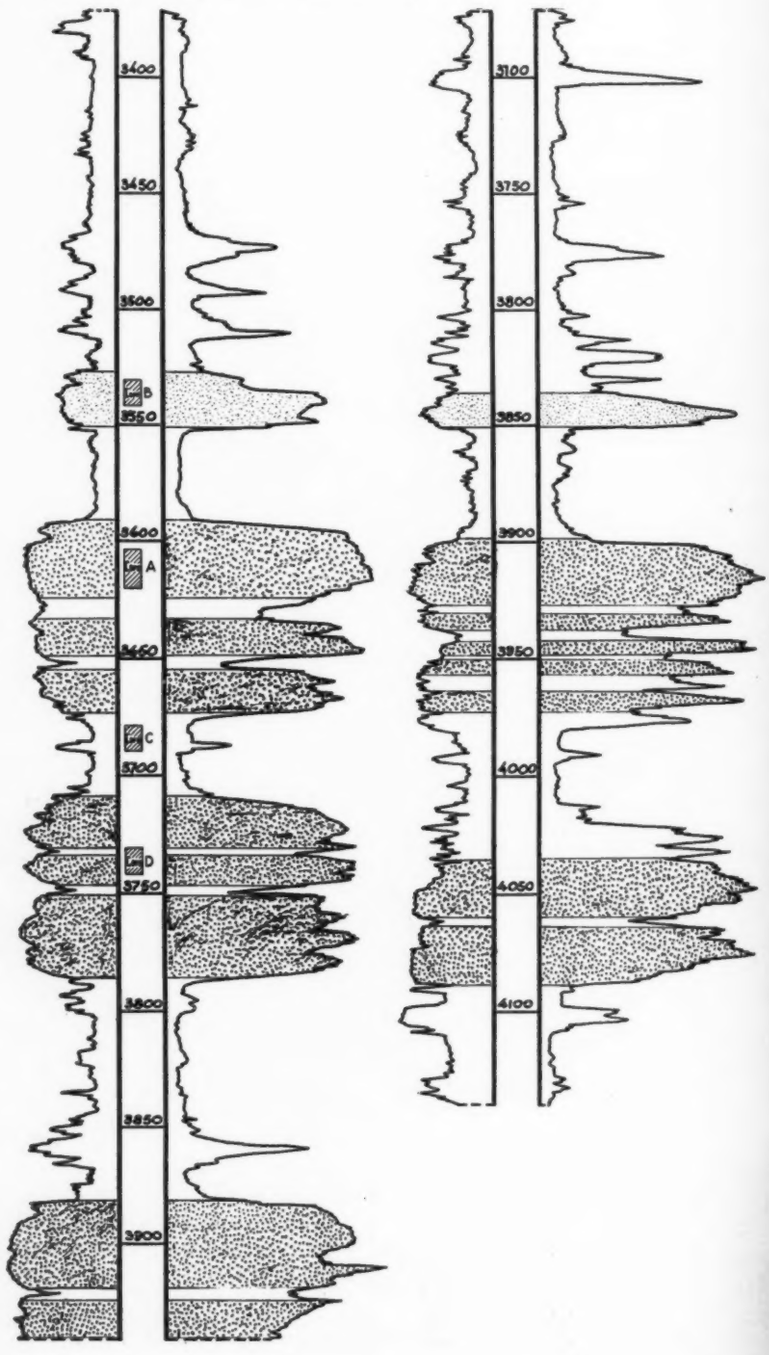

Fig. 10. Comparative sand sections

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Owing to long-continued low pressure in this well, and to its possible loading with salt water, the resistivity curve is of no value. The porosity curve alone, however, by revealing presence of the sands, was sufficient to solve the problem.

Fig. 9 shows the location of a gas flow by temperature survey in a well in West Texas.

This well originally produced 600 bbl. of oil per day. The gas-oil ratio was high to begin with and increased in two months to where the gas flow was 1½ million cu. ft., and had cut off the oil altogether. This is a good example of the simultaneous use of the three curves resistivity, porosity, and temperature. The temperature survey indicated, by a cool anomaly, that gas was coming out of the porous formation shown by the porosity log at around 2420 to 2436 feet. A new string of casing was cemented at 2436 to 2440 ft. in the hard formations revealed by the high resistivity, after which the well produced 240 bbl. of oil daily with a low gas-oil ratio.

(4) Evaluating Sands, Calculating Reserves, Estimating Potentials, Etc.

Under this heading fall some uses and possibilities of the geophysical technique that are not so well known as they should be.

The evaluating of sands is quite properly based upon cored samples that can be subjected to various tests for porosity, permeability, oil and water content, etc., but the extent to which this information from cores can be supplemented, amplified, and replaced by electrical data is only beginning to be appreciated.

Ultimately all interpretation of the electrical diagrams is based upon comparison with known occurrences, sands (containing water or oil), shales, limes, and what-not.

From the thousands of cases encountered, a fund of general information concerning interpretation has accumulated, but results differ under different conditions and all accurate interpretation in any given field, for instance, is based upon comparison with the actual conditions encountered, cores, cuttings, results of drill stem tests, completions, etc., the results in the earlier wells serving as a basis for interpretation in the later ones. As information accumulates —it may be after only a few wells have been drilled—the meaning of the various patterns on the electrical diagrams has become so well understood that this information can be substituted for the other, fewer and fewer cores are necessary, and less and less examination of cuttings. The extent to which this can be done depends upon how nearly uniform conditions are in the area in question and upon the extent of its development. Even where the coring and sampling practice is most elaborate, cores will be missed entirely at times, recovery will be poor and there always will be a chance for the electrical data to round out and complete the picture.

Fig. 10 may serve to illustrate an ideal case. Suppose that in well No. 1 cores were recovered at A, B, C, and D, and that determinations for porosity, permeability, etc., were made. The cores at A and D may be considered typical for all parts of the diagram showing approximately the same porosity and resistivity on the electrical log. These parts have been heavily stippled. B may represent a poorer sand, which is lightly stippled.

Suppose that for some reason no cores at all were obtained from well No. 2, but that conditions for the electrical survey were about as in the other well. Then it may be assumed that porosities and resistivities mean about the same as in the partly cored well and the sands may be graded accordingly. In this way the effective sand sections may be calculated and the reserve estimates improved. At Cayuga, for example, entire reliance is placed upon the electrical results for valuation of the gas

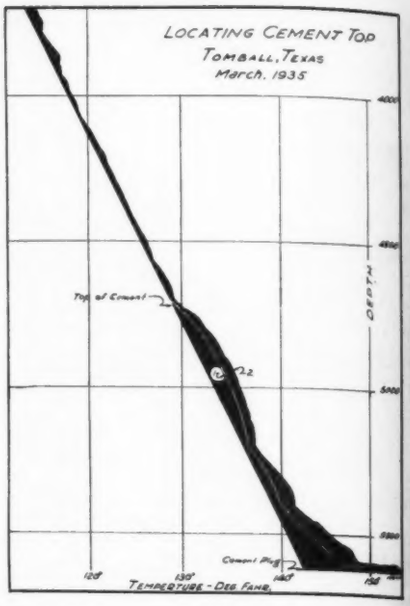

Fig. 12.

sand. The method is applicable also to such fields as Talco. Again, several lines of surveys, for cross sections, have been made in the East Texas field to get an exact record of the sand series on certain leases and in certain areas to serve as a basis for estimation of reserves. The method is applicable to a greater or less degree in almost any field, but particularly when the sand section is large.

Regarding estimates of potential: in almost any field after some data have accumulated a rough estimate of the possibilities of a new well usually can be made by comparison of the porosity and resistivity records of the sand with those of the other wells whose performance is known. In certain fields this relation is very uniform and reliable. The Edmond field in Oklahoma is one, for instance, where it holds very closely but we have no example that we can publish showing this.

Fig. 11 is an example from a field in Venezuela showing the drop in resistivity as a good oil sand changes gradually to a water sand in a distance of about half a mile. The drop in producing capacity of the wells, in this case, follows the drop in resistivity almost exactly.

The practical applications of this relationship in the way of a refinement

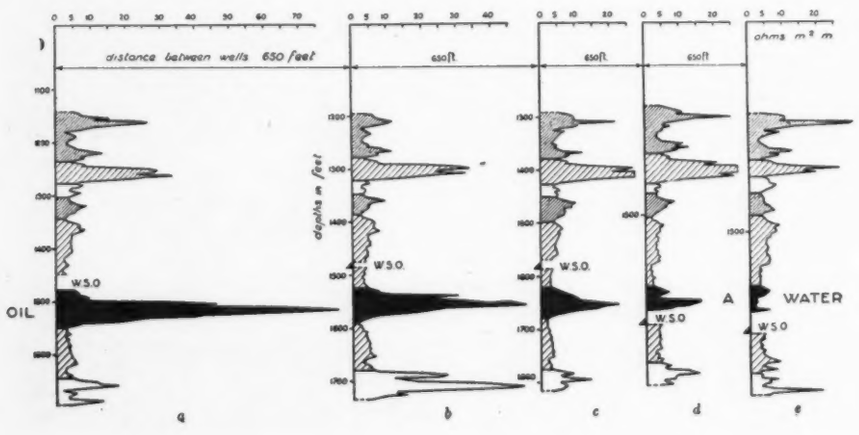

Fig. 11. Gradual transformation of a good producing sand into a water sand, Venezuela, 1930-31

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are not so obvious as those of the evaluation of the sand section, but there are such applications; for example, we understand that at Van a resistivity of 16 ohms or greater in the upper sand is a reasonably sure indication that the well will flow and that there is no need to set a packer nor to make other preparations to pump the well. We refer only to the value of the refinements of this method. Of course the ability to distinguish oil sand from water sand, and to locate certain highly resistant formations by means of the resistivity curve has practical application of the highest order.

(5) Various Applications

Checking of the casing depth is one of the objects, usually a secondary one, in connection with a great many surveys, but occasionally it is the principal or even the sole reason for the survey. There may have been a miscount of the joints or some doubt about the measurement. Since the resistivity drops to zero the moment the measuring electrodes enter the casing, this point is located as closely as it is possible to measure the cable, which is generally within a foot or two.

Junk that has been side-tracked into the wall of the hole but whose exact position is not known, may be located also by drop in the resistivity.

Presence and amount of cement around a casing can be ascertained, as already mentioned, by means of a temperature survey made within a few hours after the cement has been placed and before the heat of its setting has been dissipated. The problem often is to find out whether the cement has risen high enough around the pipe to seal off certain sands. Fig. 12 is an illustration. The increase of temperature at 4700 ft. indicates the top of the cement.

The foregoing examples do not by any means cover all applications of the Schlumberger methods to petroleum engineering problems but may serve to show the range and general character of such applications.

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View of The Texas Company's Exhibit at Texas Centennial, Dallas

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The automatic slips and hydraulic rotary table used for controlled-pressure drilling with oil on a Kettleman Hills well

Completing Rotary Wells

A discussion of the practice in California of drilling under controlled pressure in conjunction with the use of oil as a circulating fluid

COMPLETING rotary-drilled wells with oil as the circulating fluid is one of the methods of well completing being followed in several California fields. Not only is the practice adopted in wells whose formation pressure is very high, but also in those whose pressure in the productive zone is very low. Although the primary object is to obtain the greatest production possible from the well, other factors influence the selection of the method employed. This is especially true in high-pressure operations where controlled-pressure drilling is being used to meet other requirements and the results obtained have indicated that valuable data on existing conditions obtaining in the productive zone may be disclosed when operations are carefully planned.

Considering first the completion with oil in low-pressure sands, several companies are using oil as the circulating fluid in some of the fields in the Los Angeles Basin where it is believed the flow of oil into the hole is retarded by the mud sheath formed on the wall during drilling operations. This method is employed in one field when completing in an upper low-pressure sand; but when drilling is continued to a lower sand that has a higher formation pressure the more common method of completing with mud fluid is used.

When drilling through a productive sand to reach the final depth that will give the desired sand penetration it must be remembered that the colloidal properties of the drilling mud perform a definite function in preventing water from entering the sand. This protection of the sand by the mud is especially necessary in a low-pressure zone as the mud itself will not penetrate the sand but, when properly conditioned, will prevent water from filtering into the productive zone. The use of mud fluid therefore has distinct advantages during the actual making of hole through the oil sand and it is for this reason that the following method of completion with oil in low-pressure sands is being followed.

The sand is penetrated to the depth desired by ordinary drilling methods with a mud that is light in weight but conditioned to provide the necessary colloids that will insure a thin but effective plaster on the wall of the hole. Before pulling the tools after the total depth has been reached, oil is pumped in to replace the mud in the hole. A hydraulic expansion wall scraper is then run into the hole and oil used as the circulating fluid. The face of the sand is scraped, the distance scraped being determined by the depth of sand penetration.

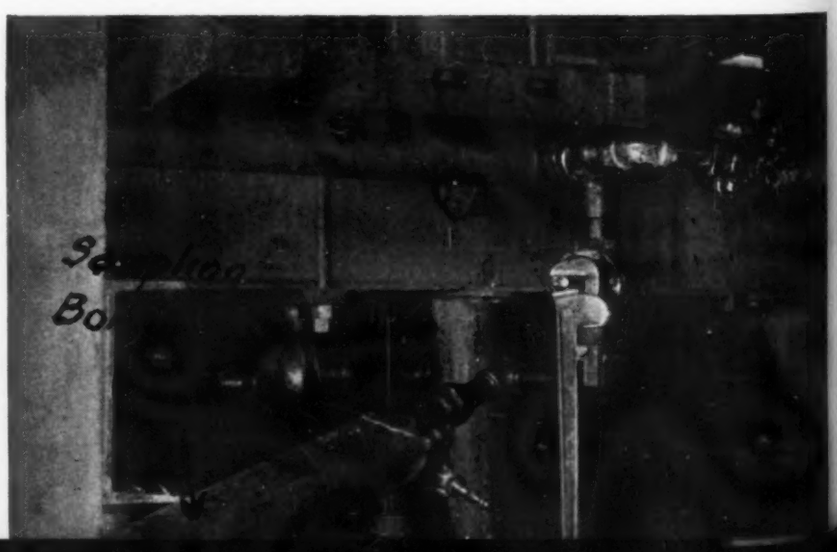
Complete removal of the mud from the face of the sand is all that is necessary and most companies merely scrape the hole to gauge. Others sometimes cut a short distance into the formation; usually this is done to make sure that all mud is removed rather than to enlarge the hole.

PRESSURE DRILLING WITH OIL

The controlled-pressure drilling method employing oil as the circulating fluid has been applied at Kettleman Hills with the very definite purpose of procuring data on the productive zones that will lead to more efficient production practice. Production tests are made at desired intervals and the oil and gas obtained are studied for the constituents of the fluid as well as the amount. From the information so obtained the completion of the well and method of production sometimes have been changed to meet the conditions prevailing at a particular location.

The adaptation of controlled-pressure drilling with oil at edge locations was the sequel to the bringing in of one well with an initial production of only 150 bbl. per day. Whether this small production was due to the tightness of the sand or because the zone was mudded off was not known. As the method of drilling-in under controlled pressure provides for making tests at any time during drilling it was believed that the production data so obtained would indicate the true condition. The differential pressure across the face of the sand can be regulated with this method and production held back during drilling. During tests, however, the pressure is kept off the sand and its production possibilities thus determined.

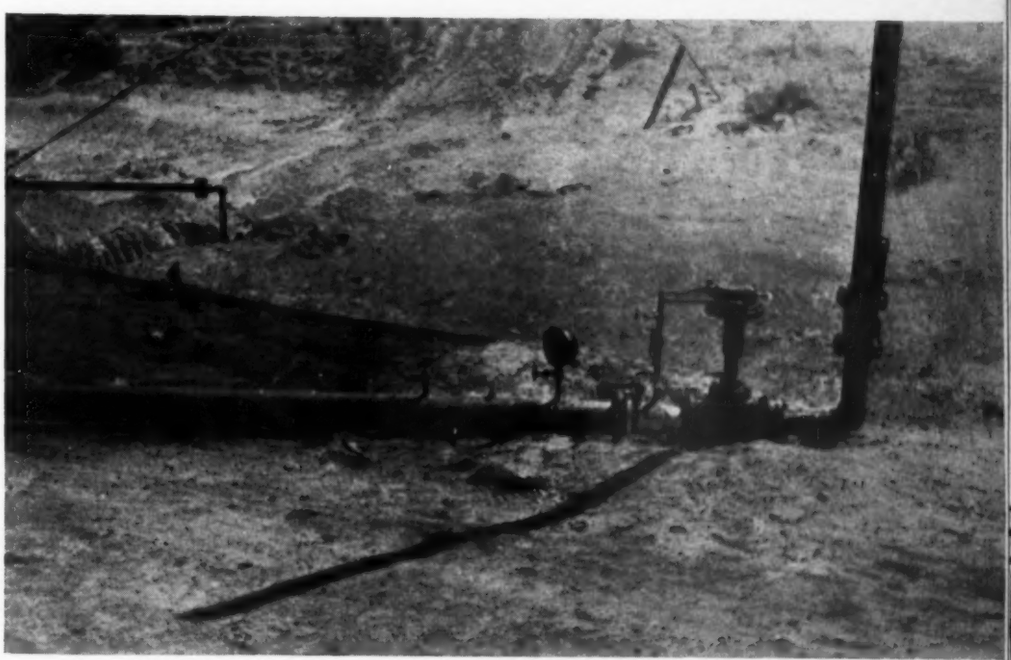
Drilling under controlled pressure with oil also provides other valuable information upon which operations can be based. In the North Dome produc-



Samples of cuttings were taken in a bomb placed on the circulation return line

With Oil

By
WALLACE A. SAWDON
Petroleum Engineer,
Los Angeles



tion is obtained from a number of zones. At edge locations where a water string is cemented directly above the productive horizon it is not possible to determine whether edge water is encroaching in any particular zone unless that zone is tested individually. No extraneous water is put into the hole when drilling under controlled pressure with oil, so any water discovered in a test must come from the formation. By testing at frequent intervals, any water that appears with the production is detected immediately and the point of water entry observed; definite data are thus obtained on the particular zones being penetrated.

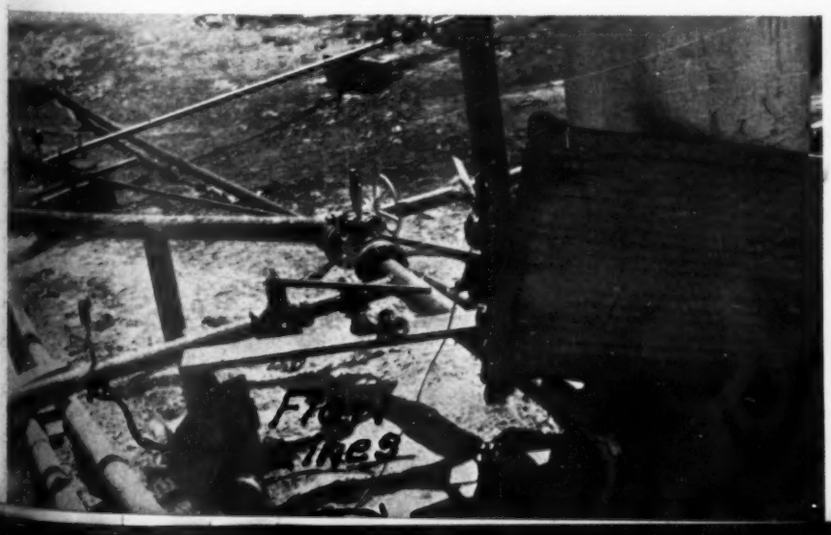
At the north end of the field the Second zone is going to gas rapidly. By drilling under controlled pressure with oil a means is provided for testing a zone as it is passed through and for estimating the actual gas-oil ratio and how the ratio will be influenced by gas zones. The well then can be completed to exclude the gas zone if desired. By thus determining whether a certain zone is predominantly gas before the well is finished, the hole can be so cased and the well completed that it will be a low-ratio well instead of a high-ratio one.

Five wells have been completed by controlled-pressure drilling with oil at various locations in the North Dome. Some have been in favorable areas and others at edge locations. In three such wells water was found to have encroached in certain zones and in one well the amount of water was 15 percent. The procedure followed in drilling the first well in this manner is here given. While tests described above were not conducted in this particular well as they were in those later drilled, the operation is indicative of the technique followed. The vertical distances being drilled under controlled pressure have been greater in some of the later wells.

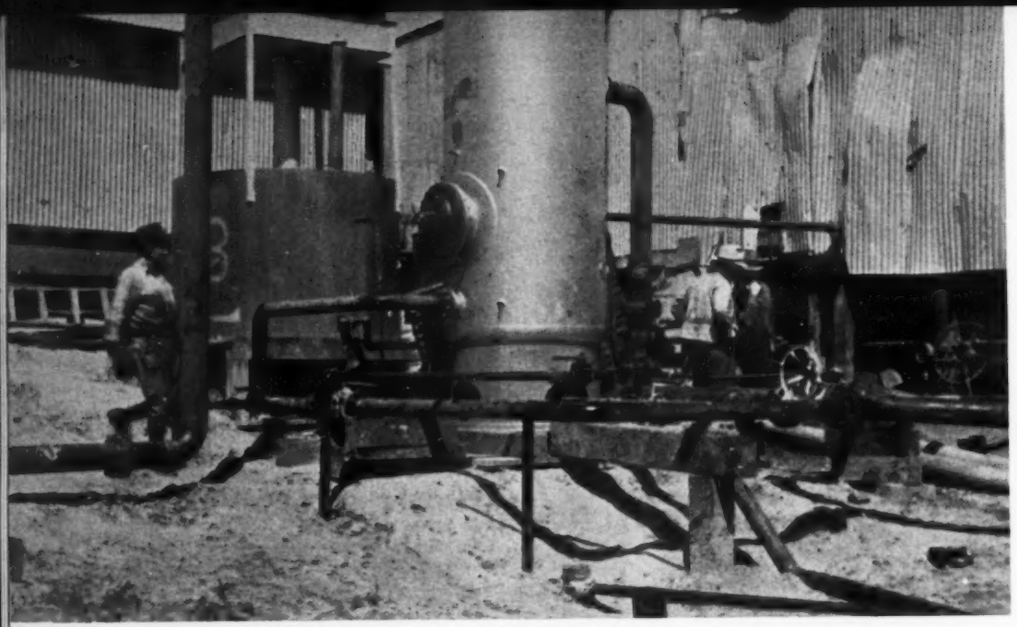
This well was drilled to 8074 ft. with mud fluid control. As shown in the accompanying sketch a string was cemented at 600 ft., a 9⅝-in. string at 7809 ft., and a 6⅝-in. water string at 8074 feet. The top of the Temblor was picked up at 7428 ft. and the usual custom of landing a 9⅝-in. string approximately 400 ft. in the Temblor was thus followed. After the 6⅝-in. casing had been cemented at 8074 ft., pressure-drilling equipment was installed and oil substituted for mud as a drilling fluid.

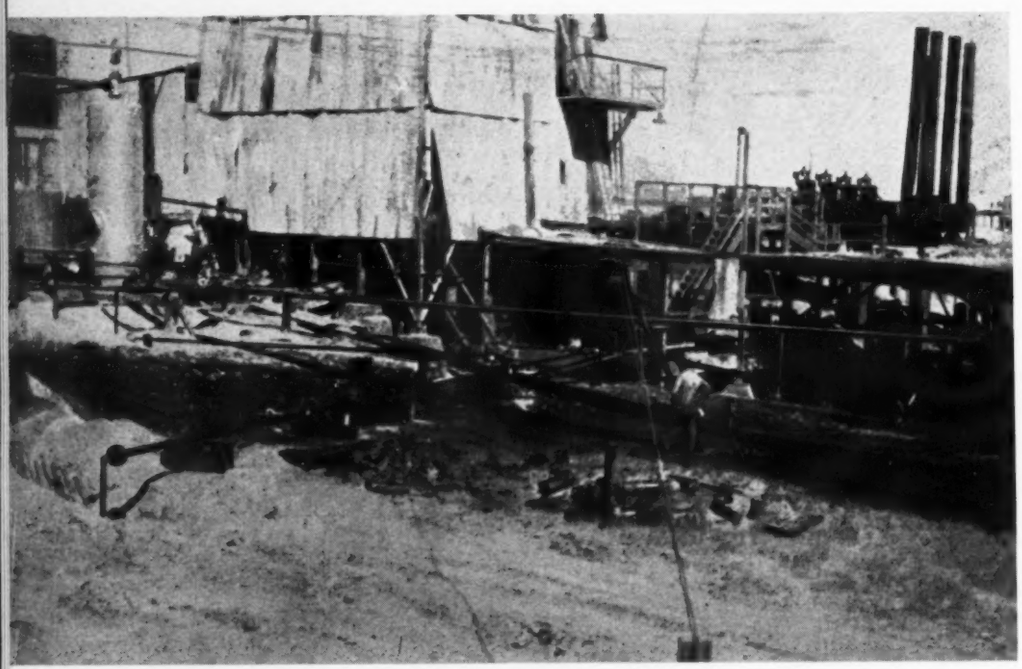
As indicated in the accompanying

Immediately above — The discharge gas line
Top of page—All input gas was accurately metered



Production during tests was carried to the separator through two flow lines





Above—View showing flow lines and input lines

illustration, a hydraulic rotary table was used with full pressure-drilling equipment on the well. The drill pipe was 3½-in external flush joint and was rotated by a 3½-in. round kelly. Below the table was a drilling packer and below this an auxiliary packer for emergency purposes and for use while changing rubbers. The casing strings were landed on a landing head above which and below the 6⅝-in. drilling gate valve was the connection for circulation returns. During drilling the pressure was regulated through this connection by means of an adjustable flow bean.

The drill pipe was snubbed-in against pressure with automatic slips and yoke. The drill pipe itself was equipped with a back-pressure valve placed just above the tool joint to prevent the flow backing up the pipe while making connections. Regular controlled pressure drilling practice was followed during actual drilling operations, the returns being passed through a vibrating screen for removal of cuttings. Samples of the cuttings were taken at intervals and studied for character of the formation.

The circulating fluid was Kettleman oil of approximately 37 deg. A.P.I. gravity. It was pumped in while drilling at a rate of about 100 bbl. an hour, being circulated like ordinary mud fluid and conditioned by a vibrating screen, by settling in the ditch, and by replacement with fresh oil. The oil was gasified by the injection of gas at a rate that ranged from 200,000 to more than 600,000 cu. ft. a day. The pump pressure on the oil was kept at approximately 1000 lb. and pressure

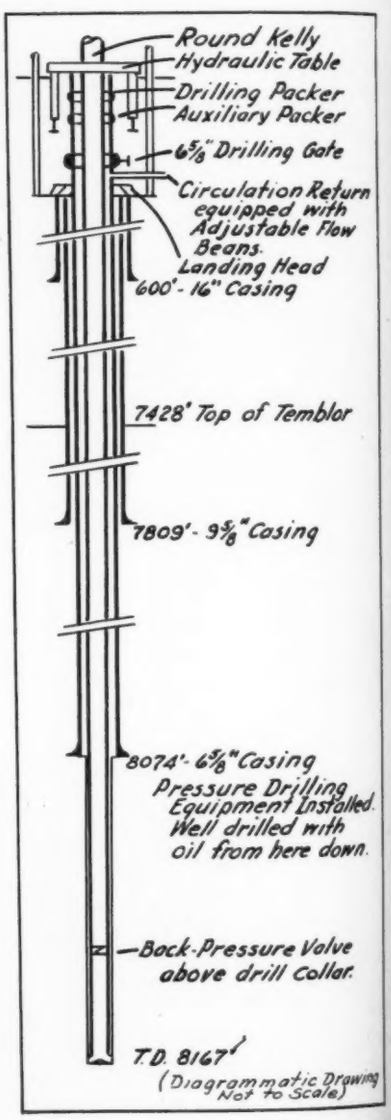
Left—The gas trap, showing the one discharge gas line

on the gas at approximately 1200 lb. per sq. inch.

The well was not allowed to gain much production while drilling, production being restricted by regulating the back-pressure and the rate of gas injection. The back-pressure on the oil and gas mixture was generally held at approximately 100 lb. per sq. in. but was at times as high as 400 lb. per sq. inch.

In order to catch samples of the cuttings during drilling a bomb was placed on the return line directly under the derrick floor as shown in an accompanying photograph. These samples were used to provide information on the formation being drilled at any particular time but were not examined

Below—Equipment used in first well drilled-in with oil under controlled pressure at Kettleman Hills, California



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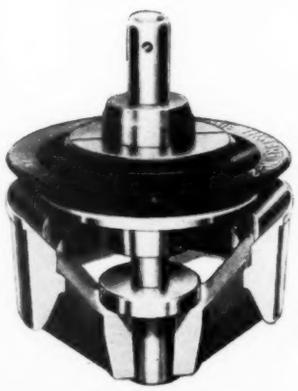

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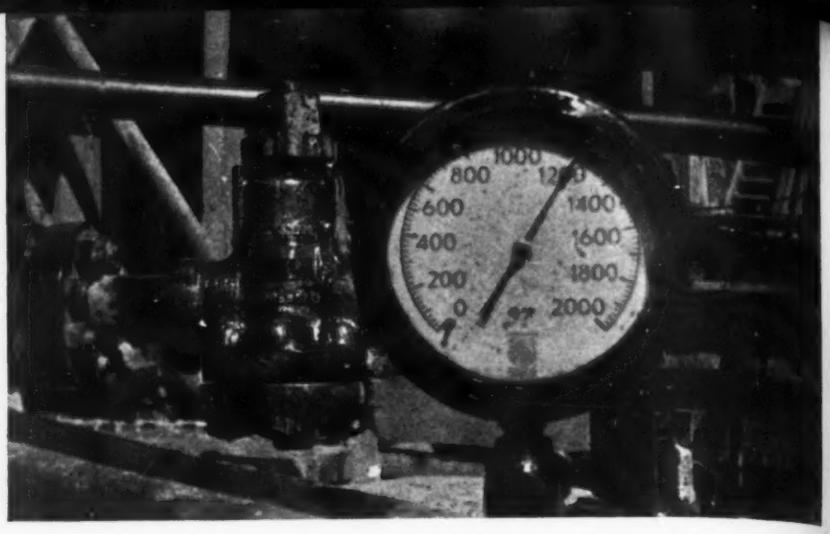

The input gas pressure was maintained at approximately 1200 lb. per sq. inch

for saturation—actual production tests provided data on the sands' productivity. It is believed that cuttings reach the surface faster with this method of drilling because of the greater velocity of the returns.

Production tests on subsequently drilled wells were made whenever desired by shutting down drilling operations and transferring the operation to gas-lift production. The oil and gas were passed through a separator where both the injected and formation gas were taken off. The input gas was accurately metered at all times and by deducting it from the total gas taken from the separator the amount of gas being produced by the well could be determined.

By using oil as the circulating fluid and controlling the pressure while drilling it is believed that a true indication of sand conditions and production can be obtained before the well is completed. The hole can then be cased to meet the subsurface conditions and the well so controlled that it will produce at its greatest efficiency. This is especially valuable in wells where the gas content is high or where water encroachment has started in a certain zone or zones.

In the first well drilled through the sand with oil the initial production with gas-lift was 2100 bbl. a day and production without gas-lift 1250 bbl. a day. A well in the immediate vicinity had an initial production of only 150 bbl. a day. It is felt, therefore, that the use of controlled-pressure drilling with oil through the productive zone provided a means for procuring the most efficient production possible. The well was equipped with 4¾-in liner perforated from 8074 to 8167 feet.

Similar practice using oil as a drilling fluid in conjunction with controlled-pressure drilling is followed in the Ventura field and some wells probably will be drilled in the same manner at Coyote Hills in the near future. In addition to the value of this practice in providing data on the content of water and gas in the oil produced, the presence of thief or low-pressure sands can be detected immediately they are penetrated by a drop in production and pressure.

Casinghead hook-up on a well in the Hauschild pool. A 6-inch flow line is used between the well and separator, which is set at some distance away at the tank battery. Flow is through a 3-in. flow bean with the 6-in. gate valve locked closed. The flow bean is set at 1-in. on this particular well.

Hauschild Pool, Western Kansas, of Interest

SIX miles east of Sterling in southern Rice County, Kansas, the Hauschild pool holds the interest of operators as being one of Western Kansas' newest gusher areas. Thirteen wells now completed have a potential of 80,000 bbl. daily, or an average of more than 6,000 bbl. per well. Heading the list of big producers in the field in the Douglas Oil and Gas Company's No. 2 Hauschild with a potential of 15,149 barrels. This is one of the largest Western Kansas wells discovered in recent months.

At the first location east of this gusher is the same company's No. 1 Hauschild, the discovery well of the field. This well was drilled-in in April of this year and was given a potential of 1280 bbl. of oil and 5,000,000 cu. ft. of gas. Since then orderly development of the field has proceeded with the larger wells adding interest as drilled-in. Each well since the discovery has exceeded it in the size of its potential. The producing horizon in this field, the Conglomerate, is found from 3365 to 3385 feet.

Leases in this pool are owned entirely by independent producers, an unusual occurrence in oil fields today. This gusher area was entirely overlooked by the major oil companies—an oversight that may be due in part to the fact that less than a mile to the northeast of the Hauschild pool is the old Wherry pool that was drilled up some years ago. Producers in the field, in addition to the Douglas Oil and Gas Company are: the Darby Petroleum Corporation, Garden and Haines, McPherson Drilling Company, and E. J. Shaffer, et al.

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GENERAL ELECTRIC

Production of Premium Diesel Fuels » »

By GEO. M. WOODS

Part 1

In this article, the first of two on the production of premium Diesel fuels, the writer discusses the effects of high-speed Diesel fuel characteristics upon engine performance and reviews the characteristics of suitable fuels for high-speed Diesel engines

THE Diesel engine has been in use for many years, but only comparatively recently have the possibilities of small, relatively light weight engines been recognized. The reduction in size and weight per hp. of Diesel engines has been accomplished mainly by increasing the engine speed. Old-style Diesel engines operated at speeds of around 400 r.p.m.; modern high-speed Diesels run in excess of 2000 revolutions per minute. These high-speed Diesels are adaptable for motive equipment. It is understood that this increase in the speed of Diesel engines has reduced the engine weight more than 80 percent per horsepower.

During the development of the high-speed Diesel engine, Diesel fuels likewise have been improved. Old-style slow-speed Diesel engines could be operated with almost any sort of fuel that could be sprayed satisfactorily; however, the new high-speed Diesel demands a high-quality fuel. Design has been found to affect greatly the fuel requirements, and progress in design and efficiency of the Diesel usually leads to less critical fuel requirements; however, at the present state of development the ready availability of high-quality fuel is very desirable in encouraging Diesel application to high-speed automobile, marine, and aircraft motor units.

The significant characteristics of present high-speed Diesel fuels obtained from petroleum fractions may be grouped under the following heads:

(1) Ignition quality.
(2) Viscosity.
(3) Specific gravity.
(4) Pour and cloud points.
(5) Boiling range.
(6) Carbon residue.
(7) Sulphur content.
(8) Color and color stability.
(9) Acidity and corrosion.

The effect of these characteristics will be discussed from the refiner's viewpoint.

Ignition quality of a Diesel fuel covers those properties that affect ignition and rate of burning. It has been observed that, in general, knocking in Diesel engines is caused by the delay between injection of the fuel and its ignition. The longer this delay, the greater the amount of fuel present at the time of ignition, which results in noise and knocking. If the delay is excessive and permits unburned fuel to reach the cylinder walls, dilution takes place in the crankcase and carbon collects in the piston ring grooves. Delay in ignition also causes excessive smoking of the Diesel.

Slight changes in design may result in improved performance of a Diesel engine far beyond that possible by altering ignition quality of the fuel over wide ranges. There are, however, very definite mechanical limitations in engine design, and where it is important to obtain good performance the ignition quality of the fuel may become a highly important factor. In the case of high-speed Diesel engines this is particularly true, and the development of a really high-speed Diesel suitable for automobile or aircraft use greatly depends on the ready availability of fuels of high ignition quality. Recent developments in Diesel aviation motors have indicated the possibilities of Diesel engines in this field.

Various petroleum stocks have been found to show a wide variation in ignition quality. The ignition quality of a Diesel fuel has been found to improve with the paraffinicity of the stock. Straight-run Diesel fuels in general have been found to possess better ignition qualities than cracked fuels, while those from paraffin-base crudes have better ignition qualities than those from asphaltic-base crudes such as Coastal and California crudes. Refining processes have been found to affect greatly Diesel fuel ignition quality. Thus, cracking lowers ignition quality, while hydrogenation raises it. Solvent extraction also can be used to split a Diesel fuel into a high-quality Diesel and a low-quality Diesel fuel. Certain "dopes" also have been found useful in increasing the ignition quality of a Diesel fuel when added in small quantities.

Various means have been used to determine the ignition quality of Diesel fuels. Most methods are based on either the time interval under standardized conditions between injection of the fuel and its ignition, or on the lowest compression pressure necessary to insure ignition of the fuel. A much easier and simpler method that permits reasonably accurate classification of Diesel fuels for ordinary purposes is the Diesel index. The Diesel index may be defined as the product of the A.P.I. gravity in degrees and the aniline point divided by 100, which are properties of the Diesel fuel that can be easily determined. The higher the paraffinicity of the stock, the better the ignition quality and the higher the Diesel index. Data on typical Diesel fuels on which the gravity, aniline point, and critical compression ratio actually have been obtained are given in Table 1.

The relationship between the critical compression ratio and the Diesel index is shown graphically in Fig. 1. As may be observed from this curve the Diesel index can be used for estimating the ignition quality of Diesel fuels. It has been found that the Diesel index may be used to classify Diesel fuels that have been prepared from straight run, cracked, hydrogenated, acid-treated,

TABLE I

CRITICAL COMPRESSION RATIO, GRAVITY, ANILINE POINT, AND DIESEL INDEX DATA ON TYPICAL DIESEL FUELS

Critical Compression Ratio	Gravity, deg. A.P.I.	Aniline Point deg. fahr.	Diesel Index
6.80	36.0	198	71
7.18	35.0	181	62
7.32	35.2	167	59
7.90	30.0	152	45
8.36	26.0	132	34

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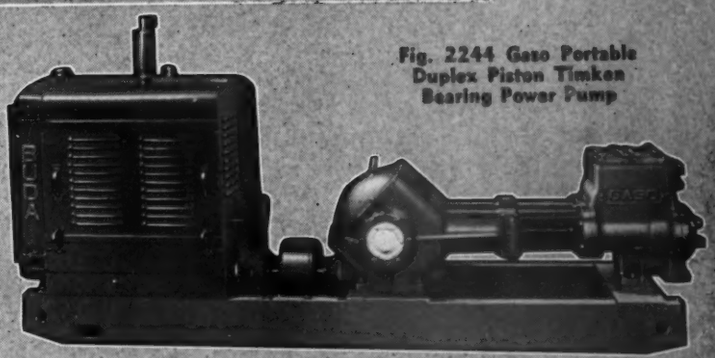

Fig. 2244 Gaso Portable Duplex Piston Timken Bearing Power Pump

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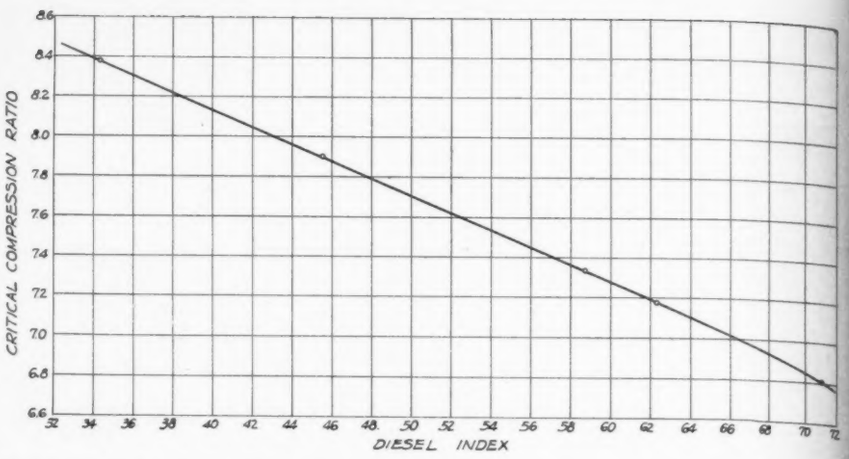
Fig. 1. Relationship between Diesel index and critical compression ratio of Diesel fuels



and solvent-extracted stocks, and various blends made from these operations. Diesel index will not, however, classify "doped" fuels that are prepared by the addition of igniting agents such as unstable oxides and nitrogen compounds.

The viscosity of a Diesel fuel bears an important relationship to the performance of the Diesel engine. A good fuel must have a viscosity low enough not to interfere with the free flow of the fuel from the storage tank to the engine through lines, handling pumps, filters, etc. The low limit of viscosity is based on the lubrication requirements of the fuel injection pump plungers and barrels. Diesel design and manufacture, however, are fast removing the lower viscosity limits of Diesel fuels. Modern engine design is eliminating rapidly the effect of viscosity on ignition characteristics, and the importance of viscosity rapidly is being restricted to lubricating requirements and to the assurance of a uniform fuel supply.

The A.P.I. gravity of a Diesel fuel of a given boiling range is a function of the paraffinicity of the stock to a certain extent. The higher the gravity (deg. A.P.I.) the higher the paraffinicity and better the ignition quality of the Diesel. The heating value per lb. of Diesel increases with increasing A.P.I. gravity, and if full use can be made of heating value, the lower A.P.I. gravity stocks, if satisfactory otherwise, may improve economy of operation to a limited extent, since most Diesel fuels are purchased on a volume basis. For aviation purposes, however, where the weight of the fuel carried is of prime importance and not the volume, the higher A.P.I. gravity stocks are very much better and should be used for better operation (more miles per lb. pay load).

The boiling range of a Diesel fuel may be defined as the range of temperatures from the initial boiling point to the final boiling point observed during a standard 200-cc. Engler distillation at atmospheric pressure. Very definite limitations on the boiling range of fuels for high-speed Diesel engines have been prescribed. At the low temperature end, the flash requirement or specifications, in the neighborhood of 150 deg. fahr., place the lowest initial boiling point at approximately 400 deg. fahrenheit. At the upper temperature end, petroleum fractions boiling above 700 deg. fahr. from crudes producing high Diesel index fuels are probably much more valuable as a source of low-viscosity high-viscosity index lubricating oil. Fractions boiling above 735 deg. fahr. tend to burn slowly in the Diesel engine and result in excessive carbon and soot formation, together with increased dilution of the lubricating oil and deposits of products of incomplete combustion in the ring grooves and pistons.

The pour and cloud points are matters of prime importance for fuels that are to be used in high-speed mobile equipment. The pour point or the temperature at which wax formation is sufficient to prevent the fuel from flowing, is a definite and serious limitation placed on Diesel fuels. If the fuel has to be pumped through filters, as is usually the case with modern high-speed Diesel engines, the cloud point, or the temperature at which wax crystals begin to form, is the limiting factor, since below this temperature the wax will clog the filters. In the case of any Diesel fuel, the pour and cloud points must be definitely higher than the minimum temperature that the fuel can attain in the fuel system. This is a very serious limitation on many of the premium Diesel fuels, as the paraffinicity of the stock is such as to cause wax formation well within the temperatures encountered in domestic latitudes. To reduce the pour or cloud points it is necessary to remove the wax, add some suitable wax inhibitor, or carefully blend selected stocks for low pour and cloud points. These methods will each be discussed fully later in this article.

The effect of sulphur content of Diesel fuels is still an open question. Much controversy exists at present concerning increased wear on cylinder barrels and liners. This question is of great importance, often contributing a major portion to the maintenance costs of high-speed Diesel engines. Suffice it to say that low sulphur content fuels at present are more desirable for high-speed Diesel engines.

The carbon residue of high-speed Diesel fuels usually are low. The value of carbon residue primarily is a safeguard against contamination in the handling and manufacturing of the fuel. Contamination of low-grade fuel or entrainment during the fractionation of the Diesel fuel would result in high-carbon residues. Carbon residues of 0.2 percent or lower should be maintained on all high-speed Diesel fuels. In general, the higher the carbon residue value, the greater the accumulation of carbon in the combustion chamber, and the greater the fouling and coking of the injector nozzles.

High-speed Diesel fuels should be non-corrosive and should be substantially neutral to acid and alkali. The use of "dopes" in fuels to improve the ignition quality should be watched closely, and easily oxidizable and unstable materials should not be used.

Cleanliness in Diesel fuels is of much greater importance than in a fuel like gasoline, since not only is the presence of foreign material hard on injector pumps and nozzles, but such material remains in suspension for long periods of time in Diesel fuel.

Color in itself has little importance to the quality of Diesel fuel, except that it indicates the care used in refining and handling the stock.

(*Editor's Note:* Part 2 of this article will appear in the forthcoming issue of *The Petroleum Engineer*, in which the writer will discuss in some detail the characteristics of Diesel fuel, with particular regard to possibilities of establishing large supplies of high-grade premium Diesel fuels from available crudes by careful selection of raw materials and suitable refining methods.)

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The photograph shows "Culler No. 9" which was drilled for the Empire Gas & Fuel Company by J. Ross McGill, contractor. The well is located in Gray County, Pampa, Texas. Those in the picture, left to right, are: W. B. Hasenfuss, Union Wire Rope Corp.; Orville Turner; O. W. Gardner, driller; C. V. Forsman, tool dresser; Fred Buckles, Jarecki Mfg. Co.; and Warren Johnson, tool pusher.

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Industry-Owned Oil Show for Houston

JOHN R. Suman, vice-president of the Humble Oil and Refining Company, and president of the Oil-World Exposition, Inc., has announced that the Oil-World Exposition will exhibit equipment for all branches of the oil industry on alternate years, the first exposition to be held October 11-16, 1937. The show will be held permanently in Houston, Texas.

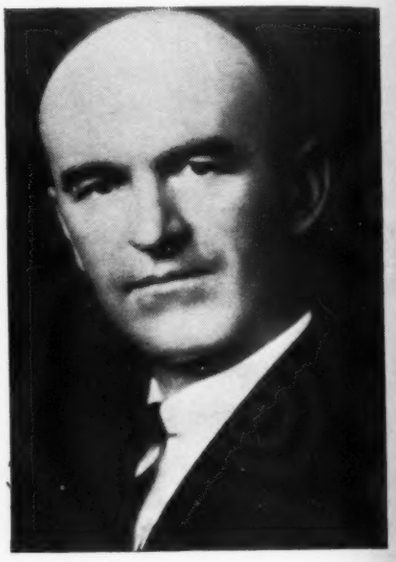
With all plans completed Oil-World Exposition, Inc., has been chartered as a non-profit organization to conduct the exposition and to present to the industry educational information on the latest developments in field and plant operations. The exposition organization is composed of oil men and manufacturers of the Gulf Coast and Texas area and the first oil show to be held under its auspices will be in the new $1,337,000 exposition hall now being built in Houston, Texas.

The importance of the Gulf Coast and Texas area in every phase of the oil industry is recognized throughout the world. In this most active territory methods naturally are being developed constantly for efficient and economical operations in producing and refining, and equipment is being designed to meet ever-changing needs. The Oil-World Exposition will aim to disseminate knowledge of modern practices and will provide means for manufacturers of oil equipment to acquaint the oil man with tools and machinery to meet the many problems with which he is confronted.

Management of the exposition will be in charge of Ed Lenzner, whose years of experience with his own oil shows in Houston and Los Angeles insures a highly-efficient exhibition. The greater facilities provided by the industry-owned oil show offer increased opportunities to assist both oil men and manufacturers and have led Lenzner to relinquish his privately-owned exposition to become general manager of Oil-World Exposition, Inc.

Memberships in the organization are held by oil men and manufacturers alike. Every manufacturer, supply company, and oil company has the opportunity to buy memberships, no one company being permitted, however, to purchase more than ten. All members have an equal vote and the privilege of expressing themselves on the exposition's policies. A large number of memberships already has been purchased, it is announced.

A board of directors composed of oil men and manufacturers has been chosen, and an executive committee appointed. The members of this committee and the board are as follows: John R. Suman, president (vice-president, Humble Oil and Refining Company); Chase Sutton, executive vice-president (division manager, Pure Oil Company); J. S. Abercrombie, vice-president (president, J. S. Abercrombie Company); George A. Hill, Jr., vice-president (president, Houston Oil Company); W. L. Childs, vice-president (vice-president, Reed Roller Bit



Left—John R. Suman, president, Oil-World Exposition, Inc.; right—Chase Sutton, executive vice-president; lower left—J. S. Abercrombie, vice-president; lower center—George A. Hill, Jr., vice-president; lower right—W. L. Childs, vice-president.

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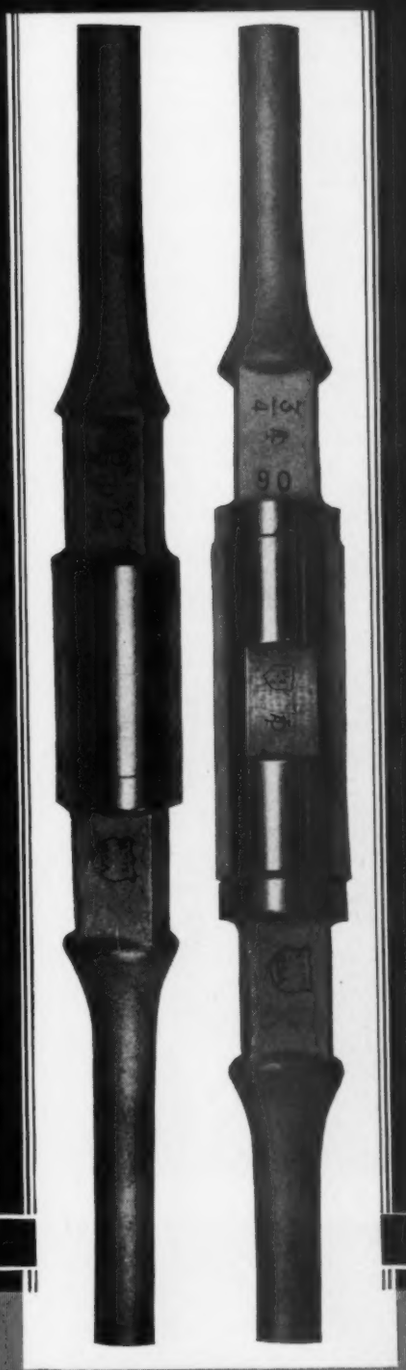

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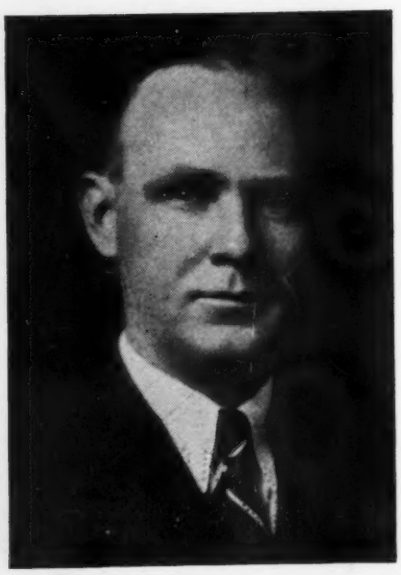
Company); Wallace Wilson, vice-president (president, Wilson Supply Company); Ray L. Dudley, secretary-treasurer (president, Gulf Publishing Company); S. P. Brown, vice-president, Hughes Tool Company; W. B. Sharp, president, Mission Manufacturing Company; Al Buchanan, president, A. A. Buchanan Drilling Contractor, San Antonio; Frank S. Carothers, manager, Norvell-Wilder Supply Company, Houston; S. T. Childress, vice-president and general manager, Rio Bravo Oil Company, Houston; H. J. Craig, sales manager, Baash-Ross Tool Company, Houston; John T. Crotty, president, Republic Supply Company, Houston; H. J. Cullinan, vice-president, Petroleum Iron Works Company of Texas, Houston; T. J. Donoghue, vice-president, The Texas Company, Houston; Harry C. Hanszen, Esperson Building, Houston; Jim Harrison, 2211 Brentwood, Houston; L. O. Koen, vice-Houston; Gage Lund, manager, The California Company, Houston; A. M. McCorkle, vice-president, Stanolind Oil and Gas Company, Houston; D. B. McDaniel, owner, Gulf Coast Drilling and Production Company, Houston; A. T. McDannald, Smith and McDannald, Houston; Robert J. Miller, Robert J. Miller Company, Houston; H. W. Millmine, president, Texas Rubber and Specialty Corporation, Houston; C. B. Moore, Frick-Reid Supply Corporation, Houston; B. M. Nowery, production superintendent, United Gas Public Service Company, Houston; George O'Leary, president, Houston Oil Field Material Company, Houston; R. W. Pack, general manager, Sun Oil Company, Beaumont; C. R. Patterson, residential manager, National Supply Company, Houston; M. W. Phelps, sales manager, Oil Well Supply Company, Houston; Joe Russell, assistant to vice-president, Gulf Production Company, Houston; T. E. Swigart, vice-president, Shell Petroleum Corporation, Houston; J. H. Teer, general manager, Layne and Bowler Company, Houston; F. H. Thrailkill, district manager, Continental Supply Company, Houston; W. C. Trout, president, Lufkin Foundry and Machine Company, Lufkin.

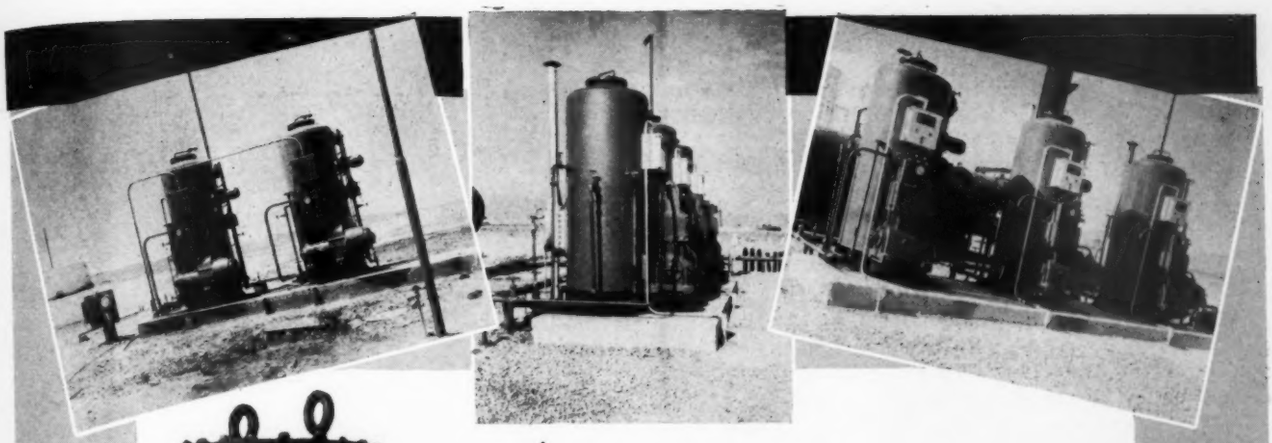
In addition to the executive committee, other committees have been appointed and some are yet to be named to work out programs of interest to technical men. One of the features of the exposition will be the holding of a special school pertaining particularly to gas measurement and control, as well as other technical matters. The school will be held in a portion of the building having a seating capacity for 1200 persons. This room will be sound-proof, air-conditioned, and will have a large stage, providing every facility. Five additional meeting and conference rooms, each seating 200 to 400 persons, also will be available.

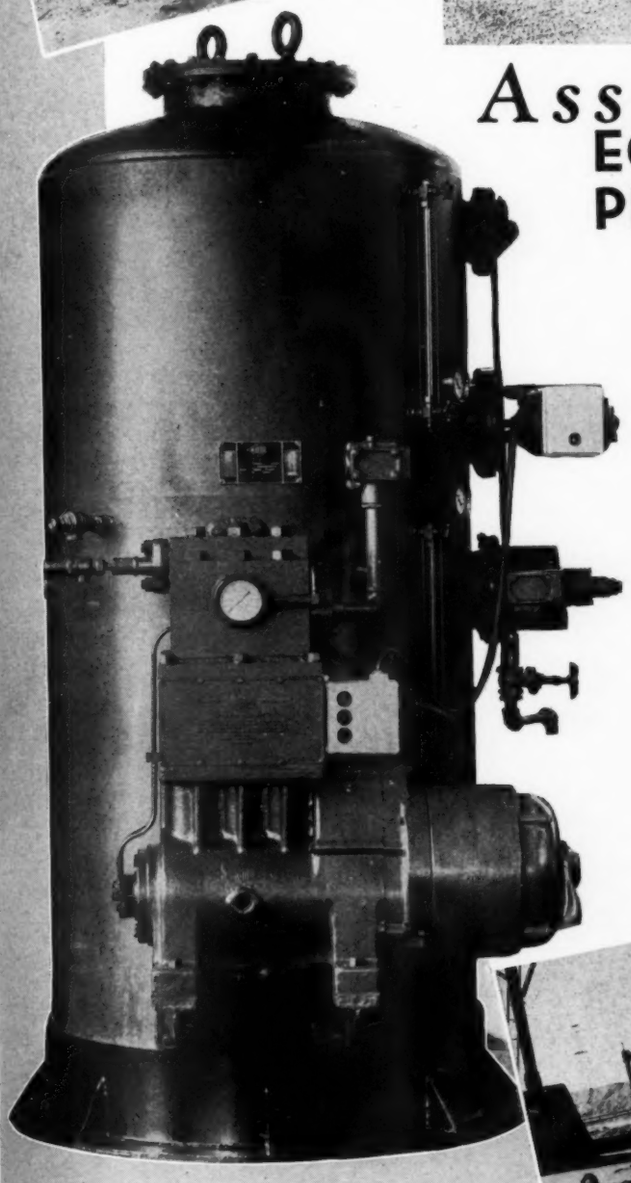
Facilities provided by the new building will be greater, with more exhibit space indoors than for any previous exposition held in Houston. The exhibit hall will contain 74,000 sq. ft. of floor space. Ground adjacent to the building will be leveled off to provide ample outdoor space for the exhibition of heavy operating equipment.

One-third of the exhibit space already has been contracted for, officials of the exposition state.



Left—Wallace Wilson, vice-president; right—W. B. Sharp, chairman, advertising committee and member executive committee; lower left—Ray L. Dudley, secretary-treasurer; lower center — Ed Lenzner, general manager; lower right—S. P. Brown, member executive committee.





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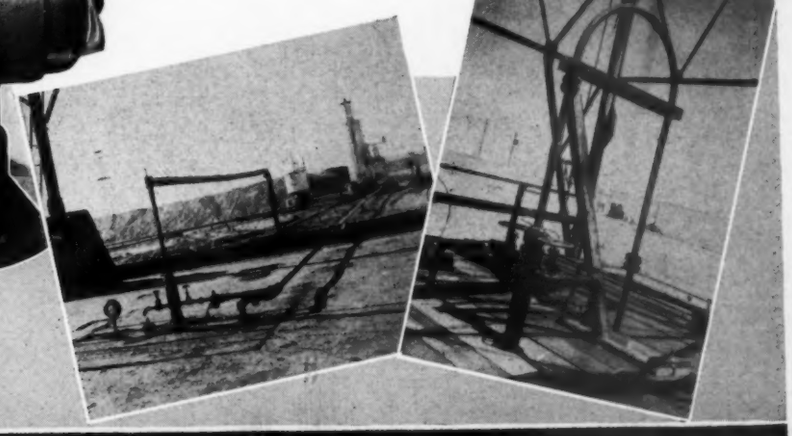

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W. N. LACEY

Formation Volumes and Energy Characteristics of Gas-Cap Material from Kettleman Hills Field[1]

By B. H. SAGE[2] and W. N. LACEY[2]

IN fields characterized by the presence of gas caps, the properties of the material occupying that portion of the sands is of interest particularly in those cases where high pressures and temperatures prevail. In these latter cases the material which is gaseous under the conditions in the formation may be expected to separate into gas and liquid phases when brought to surface-trap conditions of temperature and pressure, and probably in the flow string itself.

It was the purpose of the present investigation to study the properties of mixtures resulting from the re-combination in varying proportions of samples of gas and liquid materials obtained from the trap. Only one mixture, that having the same proportion of gas and liquid as was being produced in the trap, would be strictly characteristic of the well production. This mixture, in turn, might not be of exactly the same composition as the material in the gas cap. However, the purpose of the study was more to learn the behavior of such materials than to obtain specific information concerning the one well or field from which the samples originated.

The so-called "white-oil" production from wells high on the structure at Kettleman Hills and operating at high gas-oil ratios appears to be similar in character to that obtained under like conditions in a number of other fields. It would appear, therefore, that the behavior of samples taken from such a well in Kettleman Hills would be of nearly equal general interest in relation to all situations of the same type.

Procurement of Samples. A gas sample and a liquid sample were obtained from the high-pressure trap of a well near the middle of the gas-cap area in the Kettleman Hills field of California. The trap was operating at a pressure of 510 lb. per sq. in., absolute, and a temperature of 148 deg. fahr. at the time the samples were taken. The gas sample was obtained from the gas line leading from this trap at the same time as the liquid sample was withdrawn. At the time of the sampling the well was producing 294 bbl. of oil, 165 bbl. of water, and approximately 40,000,000 cu. ft. of gas per 24 hours. This production corresponds to a gas-oil ratio of approximately 135,000 cu. ft. of gas per barrel of oil.

The gas sample was dried at the time of sampling by passing the material through tubes containing anhydrous calcium chloride. Care was taken in the sampling of the liquid to avoid contamination with water. The oil-sample containers were completely filled and so transported to avoid separation of appreciable quantities of gas from the liquid phase. In all subsequent handling of this liquid sample, care was taken to insure that a representative portion of material was obtained when a sample was removed from the container.

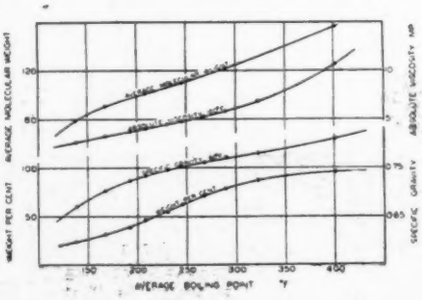
Analysis of Samples. The results of a fractionation analysis of the gas sample are reported in Table 1. Before removing a sample of gas from the original container for this analysis, the container was heated to a temperature of approximately 300 deg. fahr. to insure uniformity of composition throughout. This procedure was followed whenever a portion of gas was removed from the container. As a check upon the dependability of this procedure, a small sample container was filled after the completion of the experimental work and the greater portion of the gas had been expended. It was found that this material was practically identical in composition with that first removed from the original sample container.

TABLE 1
Analysis of Gas Sample

Constituent	Composition (Mol. Percent)	Calculated Gasoline Content (Gal. Per 1,000 cu. ft.)
Air	0.00	——
Carbon dioxide	0.00	——
Methane	83.19	——
Ethane	8.48	——
Propane	4.37	——
*Iso*butane	0.76	——
*n*Butane	1.68	0.528
*Iso*pentane	0.57	0.208
*n*Pentane	0.32	0.116
Residue (as *n*hexane)	0.63	0.258
Total	100.0	1.110
Experimentally-determined specific gravity at 60 deg. fahr. and 14.73 lb. per sq. in. referred to air	0.7082	

A satisfactory analysis of the liquid sample from the high-pressure trap is considerably more difficult to carry out than the corresponding analysis of the

Fig. 1. Results from Analytical Distillation of the Oil



[1]Paper presented at seventeenth annual meeting, American Petroleum Institute, Chicago, November 11, 1936.

[2]California Institute of Technology, Pasadena, California.

Meeting, . . . Chicago, . . . November, 1936

In this section are presented abstracts of some of the A.P.I. papers that will be of interest to our readers. Also are included the highlights of the discussion of several of the papers

B. H. SAGE

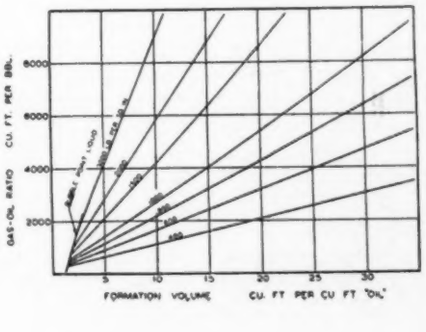
gas. The entire liquid sample taken for analysis was flashed into a large-sized "boiler" of an analytical fractionating column, such as is ordinarily used for analysis of absorber oils, and all of the material lighter than hexane was separated as overhead. This overhead material was then separated into its constituents in natural-gas-fractionation-analysis apparatus. The pentane-free material, which remained in the large boiler, was then subjected to further distillation in a flask equipped with a Hempel column. The distillate was recovered by means of a condenser through which brine at 30 deg. fahr. was circulated. The specific gravity, absolute viscosity, average molecular weight, and ASTM Engler distillation data were determined for each of the nine fractions and the residue from the Hempel distillation. The changes in some of these properties of the fractions with change in their average boiling points are presented in Fig. 1. The pentane-free material, which was subject to the Hempel distillation, will be referred to hereafter as "oil"; while the entire liquid sample, as obtained from the trap, will be called the "trap-liquid sample."

Experimental Measurements. The experimental methods utilized in the determination of the variation in formation volume and specific volume with pressure, temperature, and gas-oil ratio have been described elsewhere. The methods of calculation, and of determination of the specific heats which were employed in the evaluation of the thermo-dynamic properties of the materials, have also been described. The work relating to the volumes of the mixtures studied is considered to be dependable within the following limits: pressure, 1 lb. per sq. in.; temperature, 0.1 deg. fahr.; composition and gas-oil ratio, 0.2 percent; specific volume and formation volume, 0.3 percent.

Formation Volumes. Formation volume may be defined as the number of unit volumes occupied at a designated temperature and pressure by all the hydrocarbon material associated with one unit volume of oil as measured at 60 deg. fahr. and a pressure of 14.73 lb. per sq. in., absolute. For the purposes of this paper the "oil" will be arbitrarily chosen to be the pentane-free portion of the high-pressure trap sample. The gas-oil ratios are expressed in cubic feet of gas (including the pentane and lighter material from the trap-liquid sample) per barrel of oil. On this basis, the composition of the gas is not uniform with changes in gas-oil ratio. This variation in composition is due to the fact that the material classed as gas is derived from two sources. It is composed of a constant amount of the hydrocarbons lighter than pentane in the trap-liquid sample and varying amounts of the gas sample, whose analysis is presented in Table 1. This variation may in some cases approximate more closely actual well behavior than would the choice of gas-oil ratios expressed in terms of a gas of fixed composition.

In order to aid in the visualization of the effects of pressure, temperature, and gas-oil ratio upon the formation volume of these materials, several illustrative diagrams have been drawn. In Fig. 2 is presented the change in formation volume with gas-oil ratio at a series of pressures for 160 deg. fahrenheit. It is seen that the increase in formation volume with gas-oil ratio is nearly linear throughout the greater portion of the diagram. Fig. 3 is a similar diagram, on an enlarged scale, for the region adjacent to bubble point. Throughout most of the two-phase region, it may be safely assumed for engineering purposes that the change in formation volume at constant pressure is linear with temperature. This fact, however, is not strictly true in the region adjacent to bubble point. In Fig. 4 is presented the change in gas-oil ratio with bubble-point pressure for the three temperatures investigated. The increase in the slope of these curves at the higher bubble-point pressures is more rapid with these materials than with systems involving an oil of lower gravity.

Fig. 2. Formation Volumes at 160 deg. fahrenheit



The formation volumes reported would only be directly applicable to a reservoir whose material was composed solely of mixtures of the trap-liquid sample and the gas sample produced along with it. In most natural reservoirs this condition would not exist. The gas cap is usually in contact with that portion of the formation containing a heavier liquid phase. For this reason, if equilibrium was continuously maintained, the formation volume of the material produced from the reservoir would be somewhat different from that determined by experiments made upon mixtures of materials pro-

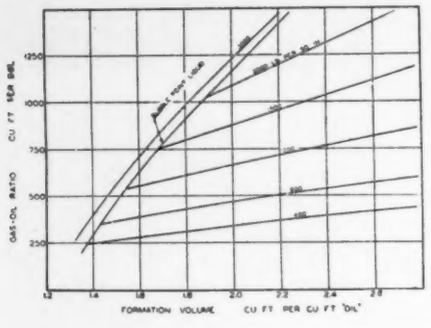


Fig. 3. Formation Volumes at 160 deg. fahr. for Low Gas-Oil Ratios.

duced from the gas cap only. These secondary effects can only be determined directly by exhaustive study of the effect of the addition of such gas-cap materials to a system containing heavier hydrocarbons. The magnitude of this divergence is reduced if equilibrium is not attained throughout the reservoir. It is believed that the results here obtained can be applied in many cases without serious error to natural reservoirs in which the gas cap co-exists with a heavier liquid phase. As the knowledge of reservoir conditions is enlarged by field studies, indications as to the attainment or non-attainment of equilibrium within and between the various parts of the reservoir during the production period will be available. Data of this type concerning reservoir behavior are of great importance in the application of experimental information, such as is recorded here, to formation conditions.

Phase Behavior. The use of "formation volumes," as such, for the presentation of the phase behavior or the energy relations of hydrocarbon systems is difficult. For these purposes it is more desirable to use specific volume, which is the volume occupied by unit weight of material.

In Fig. 5 is presented a pressure-composition diagram for 160 deg. fahrenheit. The lines of constant volume (isochores) are included as well as the bubble-point line. The intersection of the bubble-point curve with the left-hand vertical axis corresponds to the bubble-point pressure of the trap-liquid sample at 160 deg. fahrenheit. The corresponding dew point does not coincide with bubble-point in this case, since the trap-liquid sample is not a pure substance. The dew-point pressure of the liquid sample at this temperature is considerably less than 1 atmosphere. For this reason, it was not considered worthwhile to attempt an investigation of the change in dew-point with composition. However, in Fig. 5 the dew-point line would lie very slightly above the horizontal axis throughout most of the composition range there depicted. The entire area below and to the right of the bubble-point curve is in the two-phase region. The isochores are nearly straight throughout this region.

In the region of composition corresponding to nearly pure gas, the determination of the location of phase boundaries in such complex systems requires very precise and detailed knowledge of the pressure-volume-temperature relations. The data indicate that two phases persist up to compositions containing gas in excess of 93 weight percent of the total

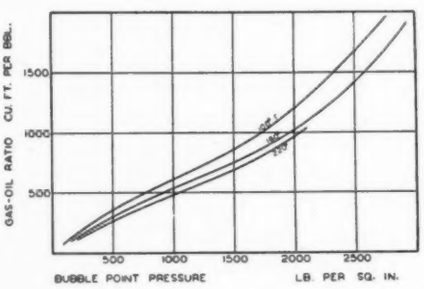


Fig. 4. Change of Bubble-Point Gas-Oil Ratio with Pressure

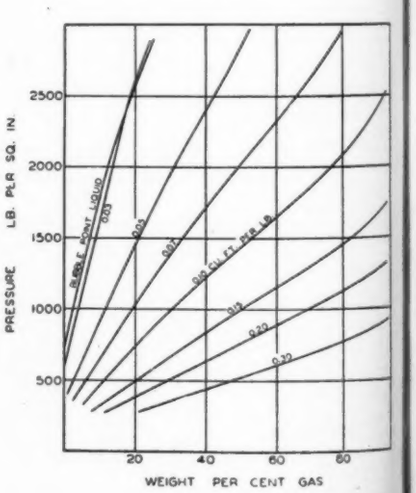
mixture. This composition corresponds to a gas-oil ratio of approximately 60,000 cu. ft. per barrel. The production gas-oil ratio at the time of sampling was about 135,000 cu. ft. per barrel. It, therefore, appears that this material is being produced primarily from a gaseous phase within the formation. Under the conditions of the laboratory experiments, there might be an unmeasureable trace of liquid phase present even at gas-oil ratio as high as 135,000 cu. ft. per barrel. This trace of liquid material would, however, be taken up by the gas phase if the latter were to be brought to equilibrium with a body of liquid oil such as would be found in the formation.

It is of interest to compare the behavior of these mixtures of high gas-oil ratio with that of a perfect gas. In Fig. 6 is plotted, for 160 deg. fahr., the pressure-volume product of each of these materials as a function of the pressure. The behavior of a perfect gas would be shown in this diagram by a horizontal straight line. The appreciable effect of small amounts of heavier hydrocarbons upon the pressure-volume behavior of these materials is evident.

Thermodynamic Properties. Because of the dearth of such information for natural gases, a detailed investigation of the thermodynamic behavior of the trap-gas sample was made. In Fig. 7 is shown the ratio of the pressure-volume product at a given pressure and temperature to the pressure-volume product at the same temperature for a pressure of 1 atmosphere. From these data and information as to the variation of specific heat with temperature, the variation of the specific values of heat content and entropy with pressure and temperature have been calculated. The isobaric specific heats at atmospheric pressure were determined by the adiabatic expansion method. It was found that the experimentally - determined isobaric specific heats agreed within the experimental uncertainty with those calculated on the basis of ideal solutions from such information for the individual constituents.

The thermodynamic properties of hydrocarbon mixtures similar to the trap-liquid sample are also sufficiently little known to make an evaluation of these properties worthwhile. Specific values of volume, heat content, and entropy, were based upon experimentally-determined pressure-volume-temperature relations and the isochoric specific heat values depicted in Fig. 8. These specific heats were determined in an adiabatic calorimeter, and are considered dependable within one percent. Since the pressure-volume-temperature measurements were to be used in the calculation of heat content and en-

Fig. 5. Pressure-Composition Diagram for 160 deg. fahrenheit



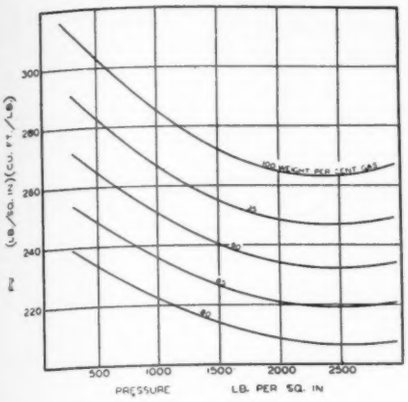


Fig. 6. Compressibility of High-Gas-Oil-Ratio Mixtures at 160 deg. fahrenheit

tropy, the experimental measurements were carried out with greater precision for this particular material. It is believed that the experimental uncertainty is within the following limits: pressure, 0.5 lb. per sq. in.; temperature, 0.02 deg. fahr.; specific volume, 0.1 percent. The values of heat content and entropy were carried to at least one more significant figure than was warranted by the accuracy of the specific-heat measurements, in order to show the isothermal changes in these properties with satisfactory accuracy.

HIGHLIGHTS OF THE DISCUSSION

Fred E. Wood, Standard Oil Company of Indiana, Chicago, in opening the discussion pointed out that methods of estimating reserves have changed in the last decade. Instead of simple porosity-saturation determinations connate water and also the physical properties of the hydrocarbon components and their behavior under high pressure and temperature are now being taken into consideration, for it is found that these can influence greatly reserve estimates.

A. W. Ambrose, Empire Companies, Bartlesville, Oklahoma, mentioned a problem met in the transmission of wet gas that might be explained by Dr. Lacey. It was observed that when pumping wet gas under high pressure an increase of pressure would make the wet gas approach a liquid in its reaction to pumping. Connections would break off due to an action similar to water-hammer in the line. Dr. Lacey explained that when pressure and temperature are high and are in the critical region you cannot tell what you have because your liquid and gas approach each other and may both reach one and the same phase.

H. D. Wilde, Jr., Humble Oil & Refining Company, Houston, Texas, asked Dr. Lacey if he interpreted the "white oil" he spoke of as being in the critical phase in the gas cap. Dr. Lacey was of the opinion that the hydrocarbons in the gas cap of the Kettleman Hills field were not in two phases, liquid and gas, but in one phase, the critical, and that the "white oil" was a condensate, due to the reduction in temperature and pressure of the hydrocarbons on their way to the surface.

In reply to a question by F. R. Schmieder, Shell Oil Company, Los Angeles, California, regarding whether tables could not be made for hydrocarbons similar to steam tables, Dr. Lacey said, in effect, that the studies are really to that end; to be able to predict points of equilibrium, volume occupied, thermodynamic properties, etc., the same as is done for steam. A steam table is simple in comparison with one for hydrocarbons. A steam table is for a single component, whereas a table for hydrocarbons must be made for a number of components. The tremendous task of preparing such a table is in progress, at least for the numerous hydrocarbon combinations in the ranges of pressure and temperature that might be found useful in practice.

An interesting point was brought up for discussion by Fred E. Wood regarding the reduction in volume in the reservoir, Kettleman Hills, due to the hydrocarbons being under high pressure and temperature beyond or in the region of the critical in the light of his studies. It was brought out by Dr. Lacey that under the prevailing pressure and temperature in the reservoir, 1½ bbl. to 3½ bbl. (under normal surface conditions) will occupy the space of only one barrel in the sand. In this connection it was also brought out that as gas is produced from the reservoir and the gas phase is allowed to expand the space occupied by a barrel of oil in the sand will increase.

This brought a question from E. O. Bennett, Continental Oil Company, Ponca City, regarding the maintenance of pressure in a field at some point near the original reservoir pressure by returning the gas to the sand. Dr. Lacey pointed out that the question of the pressure to maintain would depend on the local conditions, the physical conditions in the reservoir, and on the producing conditions. If there is good water-drive it may not be necessary to return all the gas produced. Maintenance of pressure is very desirable, but it may be done in different ways.

R. A. Cattell, U. S. Bureau of Mines, Washington, D. C., in discussing Lacey and Sage's paper pointed out how we must change our whole conception of the nature and behavior of oil and gas under high pressure and temperature in the region of the critical.

In reply to a question by C. A. P. Southwell, Anglo-Iranian Oil Company, London, England, regarding whether any work on specific samples from other fields was being carried out by the companies themselves, it was brought out by Dr. Lacey that some companies are embarking on this work and that their (Lacey and Sage) studies could be aided greatly by studies of specific samples from specific reservoirs. Dr. Lacey pointed out that he was concerned chiefly with the general problem of formation volumes and energy characteristics of hydrocarbons in the reservoir.

Fig. 7. Compressibility of the Natural Gas

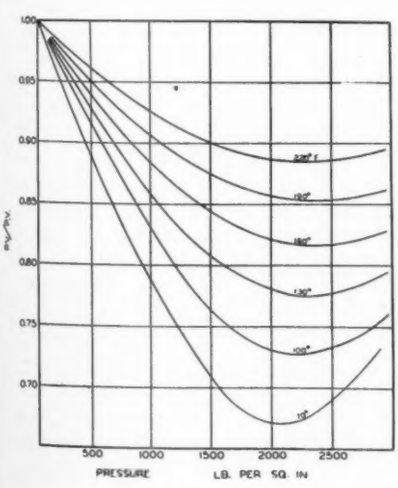
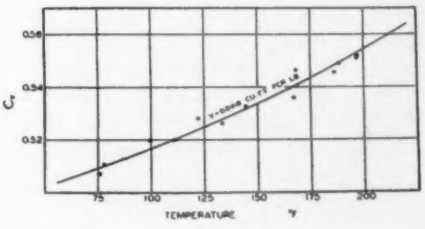


Fig. 8. Specific Heat at Constant Volume of Trap-Liquid Sample



Wm. HOWARD CLAPP

The Relation of Mechanical Testing to Steel Performance[1]

By WILLIAM HOWARD CLAPP[2]

IS THERE a best steel to use for a given service? Is there a best steel for elevator links or drill pipe or sucker rods? If so, are there any ways of determining this steel other than the expensive and time-consuming one of trial and error? To what extent are the results of mechanical testing an index of performance? These questions have an importance today which was little realized a few years ago. Oil wells are spudded in today to tap sands some two miles below the surface. Soon it may be necessary to pump from these depths. In spite of the improvement in engineering steels, equipment is being forced closer and closer to the limits of performance.

For uses where the service is especially severe there is a wide diversity of opinion as to the best type of steel to be used. Sometimes a change to a different type of steel results in improved performance; frequently a change to a more expensive steel results in even poorer performance. Why this is so, nobody seems to know; but the new steel gets a black eye. We need a clearer picture of the relative importance of those factors upon which the selection of a steel is usually based. If our present knowledge of the mechanical properties of a steel gives us an incomplete picture of its performance, it will be worth something to know that. This paper is an attempt to contribute something toward a clearer view of the problem of steel selection.

Recently the writer assembled the data of every reliable mechanical test which he could find in the literature of the last 10 years—tests made by careful investigators not connected with any steel manufacturer. No tests were included unless the chemical composition of the steel and the heat treatment were given. The data from these tests were plotted against the tensile strength of the steel—putting on separate charts such quantities as proportional limit, yield point, elongation, endurance limit, impact strength, etc., and using a separate designation for each type of steel. It was anticipated that these charts would bring out the superiority of certain steels in one or more of these respects. The results of many hundreds of tests gave little indication of any such superiority. If, for example, one of these steels showed many tests with superior yield points at a given tensile strength, there were other tests in which the yield point was distinctly inferior. One could only conclude that while, on the average, some one steel would be superior in some respect, there was a distinct possibility that it might be inferior.

We do not need to go beyond the data furnished by the steel manufacturers themselves to see why this should be so. For example, one corporation which is interested in promoting the use of a certain alloying element in steel publishes an instructive booklet which furnishes curves of mechanical properties of nickel and nickel-chromium steels. They also give maximum and minimum values of these properties which may be expected to occur when a standard test specimen, which has been turned down from a rolled bar about 1 in. in diameter, is carefully heat-treated and carefully tested. The mechanical properties are plotted against the tempering temperature which is convenient for the user, although does not give a proper basis for comparison of different steels. In Fig. 1 the elastic limits of SAE 3135, 3435, and 2335 steels are plotted against corresponding tensile strength, and are shown as curves on the chart. The unconnected points represent maximum and minimum values, which are plotted against the mean value in each case. It is apparent that the variation in any one steel may be much greater than the variation in the average values for the three steels.

Can the designer say that a steel which has a slightly higher yield point and a slightly lower elongation than another is superior to the other in which these relations are reversed? We must admit that, while these two properties are important indicators of steel behavior, we do not know what relative importance to attach to either one of them. A high elastic limit would probably be considered more important for steady load conditions, while good elongation is one of the toughness factors that is valuable in combating occasional overload. But, here again, service conditions vary widely, and designers can only guess as to the relative importance of these two important factors.

The chief reason why we cannot definitely select any one steel for a given service on the basis of mechanical testing is that we do not as yet know why metals fail for any condition of service; i.e., we do not know with exactness what the *physical factors* are which determine the limits of performance of a steel for any kind of loading. This statement may seem a heresy to many who have been led to believe that the results of mechanical testing furnish an absolute index of performance. It would lessen the general confusion that exists on the question of steel selection if this fact were more generally understood and appreciated.

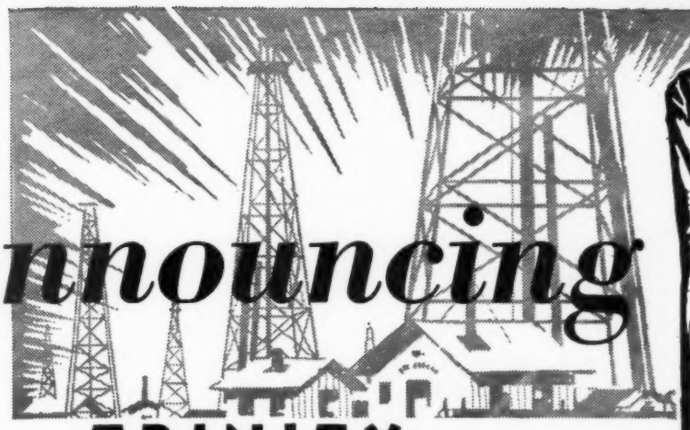
Four different types of steel failure are recognized:

a. The ductile type of failure, brought about by an overload.
b. The brittle type of failure, which takes place because of sudden shock (impact).
c. The progressive type of failure, which occurs when material is subjected to variations in stress and usually after a large number of repetitions of stress (fatigue).
d. The exceedingly slow but continuous stretch of steel under load at high temperatures (creep).

Each of these types of failure is distinctly different from the others. Each of them occurs as a result of exceeding some certain physical limitations in the

[1]Paper presented at seventeenth annual meeting, American Petroleum Institute, Chicago, November 10, 1936.

[2]California Institute of Technology, Pasadena, California.



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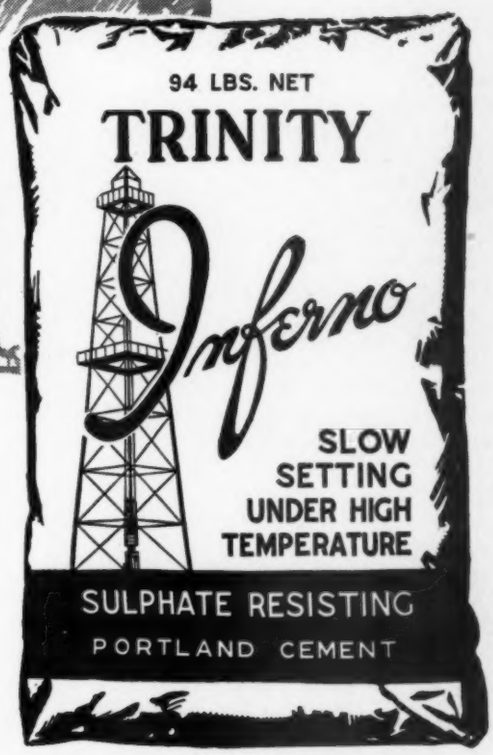

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2 hrs. 40 min.	3 hrs. 8 min.	150	3 hrs. 0 min.	3 hrs. 35 min.
3 hrs. 20 min.	4 hrs. 20 min.	100	4 hrs. 5 min.	5 hrs. 5 min.
5 hrs. 50 min.	8 hrs. 0 min.	70	8 hrs. 25 min.	10 hrs. 40 min.

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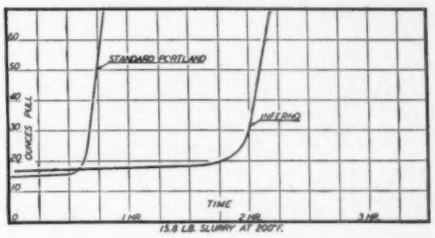
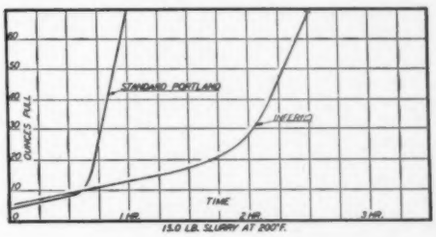


15.8 LB. SLURRY AT 200°F.



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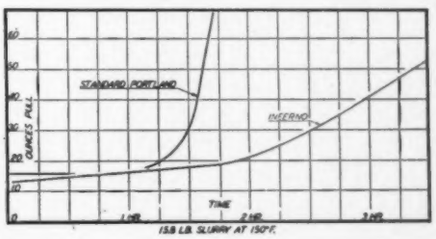
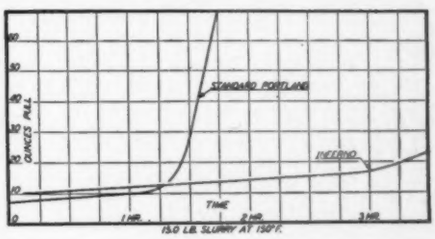


15.8 LB. SLURRY AT 150°F.



15.0 LB. SLURRY AT 150°F.

steel. Each of them may be hastened by corrosive attack. All research work in mechanical testing is directed toward a better understanding of these physical factors of the metal. Why does steel fail? What are the real limits of its performance?

The Ductile Type of Failure. Here the rupture of the metal in tension is preceded by stretching and "necking down" at the point of break. The appearance of the fracture is similar to that of the broken tensile test specimen, and the data from the tension test furnish the most reliable index of performance. Consider a tension test specimen of heat-treated alloy steel. We will assume that the modulus of elasticity of the steel is 30,000,000 lb. per sq. in., that the torsional modulus is 11,530,000 lb. per sq. in., and that the elastic limit of the steel as determined in the tensile test is 120,000 lb. per sq. inch. Let us assume that in using this steel no yielding of the metal shall be permitted. This first measurable permanent set occurs when the elastic limit is reached in the tensile test.

Why does permanent set occur when the elastic limit is reached in the tensile test? The answer to this question is that we do not know. We write here five different quantities which may be calculated from the above test. Each of these has been used by designers as a "determinant of failure":

a. The elastic limit strength, 120,000 lb. per sq. inch.
b. The limiting strain, 0.004 in. per inch.
c. The maximum induced shear stress, 60,000 lb. per sq. inch.
d. The resilience or total strain energy, 240 in.-lb. per cu. inch.
e. The strain energy of distortion, 208 in-lb. per cu. inch.

These five different standards of measurement are calculated from the data of the preceding paragraph, and the five quantities are arrived at simultaneously in the test. Now why does the metal take a permanent set at this limit? Is it because the tensile stress reaches a critical value of 120,000 lb. per sq. in., or because the strain reaches a critical value of 0.004 in. per in., or because one of the other three factors sets a limit to elastic cohesion, or because of some other more involved condition? One might imagine that it would not make any difference to the designer, since all five values are reached simultaneously in the test. While this is true for the simple tension test, however, *it is not true for more complicated conditions of loading.*

The writer has attempted to show: 1, that the tensile properties of the standard SAE steels do not differ widely from each other when these properties are compared on a basis of similar tensile strengths; 2, that the variation in these properties for any one type of steel and a given heat treatment may exceed the variation in the average value of such properties as exhibited by the different members of the group; and, 3, that under steady load conditions, for which the designer assumes that the limiting load is determined by a permanent set, there is an uncertainty with regard to the physical factors of the metal that determine yielding. This uncertainty results in a difference of opinion as to the limiting load which may be applied.

Failure Caused by Sudden Shock (Impact). Steady load conditions are almost never found in oil-field service. At the other extreme of loading is the failure brought about by abrupt applications of load. A steel which fails in a ductile manner under steady load may be as brittle as a brick under sudden shock. In the first case the fractured surface is fine-grained and silky; in the second, coarse and granular. The two types of failure are distinctly different. Different physical factors set the limits of performance in the two cases. What measure do the standard laboratory tests give us of the performance of steel under shock?

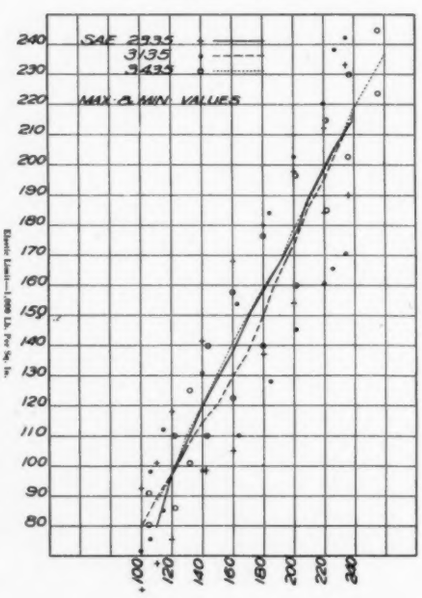
We learn something from the standard tensile test. When a bar is tested in tension, the stresses set up in the bar are independent of its length. Increasing the length will not affect the elastic limit or the yield point or the elongation in 2 in., or the breaking strength. If the bar is broken in tension by a sudden blow (tension impact) the longer bar will withstand a heavier blow. This is because it will stretch more. The capacity to elongate under shock is one of the important qualities of a steel for resisting impact.

Very important also is the effect of the character of the surface of the specimen. If fine threads are cut on the tensile test piece, its elongation will be greatly reduced—although its static strength may even be increased. The capacity of such a bar to absorb the energy of tension impact has been reduced almost to zero in spite of its high static strength. A recent test performed by Ludwik and Schau illustrates very neatly this effect of shape upon the tensile properties. Six specimens, as shown in Fig. 2, are carefully turned so that the mid-section diameter in each case is 10 mm. The first specimen is a straight cylindrical bar; the next has a long double taper, the two slopes connecting with a small arc; in the next three the length of the taper is decreased so that the shape approaches that of a notched bar. The last specimen is a true notch, with parallel sides and sharp corners.

Increasing the sharpness of the notch increases the static strength of the bar. This is because the shape of the notch acts to prevent plastic deformation. The bar cannot neck down so much before breaking. The most important effect is the sharp reduction in over-all elongation as the notch is made sharper. Bar *A* elongates nearly 24 times as much as bar *F*. The estimated work of rupture gives a rough comparison of the shock-absorbing capacity of the different specimens if the shock is a tension impact. Under any shock loading, abrupt changes in cross-section, grooves, notches, and other irregularities of shape *act to restrict the volume of metal which can be deformed,* so that the capacity to withstand shock is greatly diminished. These considerations are general, and apply to all types of steel.

This effect of the notch, in preventing plastic flow and reducing the volume of deformable metal, has led to the general use of the standard notched-bar tests of the Charpy and Izod types. The effects of the shape of the test bar and the shape of the notch upon the impact strength of the bar have been studied. These effects are so considerable that comparison of different steels must always be made with similarly-shaped bars. When this is done, it is found that there is a variation in the behavior of different steels which is out of all proportion to their relative behavior in the tensile test. Some steels have high "notch toughness." They deform considerably be-

Fig. 1. Ultimate tensile strength—100 lb. per sq. inch



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fore breaking, and have a high impact value. Other steels are "notch sensitive," and break easily with little deformation. Both steels may have equally good tensile properties—even to the elongation. It is evident that there is some property of a steel which has an important bearing on shock resistance, and which is not brought out by the tension test. Experience confirms this, as all of us have seen bars of steel which broke into fragments (like a brittle cast iron) when dropped to the floor; or crane hooks, and other curved members, which fractured brittlely under sudden impact. The same steels when tested in tension had good elongations and yield-point strengths. Many tests have been carried out on steels having similar tensile properties to show that one had high notch toughness while the other was weak and brittle.

But it is not possible to say that one type of SAE alloy steel is superior and another type inferior in notch toughness. The difference is rather in the structure of the steel as determined by manufacture or by heat treatment. Hoyt lists 11 "conditions" which confer notch sensitiveness upon a steel:

1. Casting structure.
2. Over-heated condition from forging.
3. Over-heated or poor condition from heat treatment.
4. Low-temperature brittleness.
5. Temper brittleness in some heat-treated steels.
6. Aging, embrittlement in mild steels.
7. Phosphorous, oxygen, etc.
8. Segregations.
9. Laminations.
10. Coarse slag or foreign inclusions.
11. "Condition" of steel as affected by melting, refining and deoxidation practice.

Some of these conditions may be easily detected either with or without the microscope. Others cannot be detected by any means but the notched-bar test. The last one is as general as a plank in a party platform.

There is a wide difference of opinion among designers as to the value of the impact test. The notched-bar test gives us no absolute measure of steel performance. It sets up no yardstick which the designer can use in a quantitative way. Tests are now being made looking toward the establishment of a new physical unit, "cleavage strength," in which high cleavage strength combined with fairly low yield strength would be a measure of notch toughness. Until we learn much more about why steels fail, the designer is warranted in demanding good impact values in steel which must withstand shock loading.

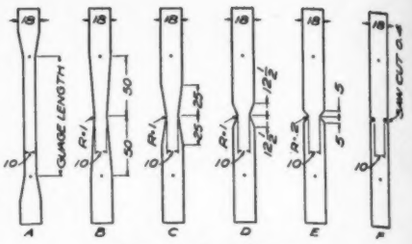
It should be kept clearly in mind that the notched-bar test is a most drastic one, and that similar conditions are practically never found in service.

Failure by Progressive Fracture (Fatigue). This is the abrupt rupture of a part which has withstood a large number of repeated changes of load. The metal breaks suddenly, without warning, under a load which it had up to that time sustained. It is now known that this type of failure starts as a microscopic crack, usually at the surface of the metal. The crack acts as the "sharpest sort of notch." High stresses are set up at the bottom of the crack, while plastic deformation is restricted. With each alternation of load these stresses pry away at the tiny crystal grain at the bottom of the crack. In time each grain gives way, and is split apart. Thus the crack is slowly deepened and widened. Rupture occurs when the metal section has been reduced so much that it can no longer carry the load. The first, or progressive, portion of the break is a brittle one; the final rupture shows the plastic deformation of ductile breaks with the softer steels or the shatter type of brittle break with harder steels.

For the design of machine members against fatigue, the designer uses the so-called "endurance limit" of the metal. The steel user should know to what extent the endurance limit may be considered a reliable index of performance.

In applying the endurance limit to service conditions, it is necessary to consider certain limitations. We know that steel is not always sound. Steel as received may have cracks such as seams, cold shuts, flakes, and forging bursts. There are the grinding cracks and quenching cracks of machining and heat treatment. These cracks are readily spread at low loads to cause fatigue failure. Again cracks may form in an otherwise sound steel because of stress concentration. These stress raisers may be internal, resulting from inclusions, forging strains, etc.; or they may be produced at the surface from notch effects, such as scratches, tool marks, hammer dents, screw threads, inadequate fillets, poorly-placed holes, etc. Some of these defects can be avoided by the designer; some of them may be prevented in the shop; the others must be referred to the metallurgist. Sound steel, soundly designed, should be obtainable.

In spite of the millions of endurance tests which have been carried out in the last 15 years, we do not know what to expect from a piece of steel in service under varying load conditions. A larger factor of safety must be used than for fairly steady loads, because of



Dimensions in millimeters.

Fig. 2. Notched cylindrical tensile test bars

uncertainty with regard to starting a crack. We do not know the relation between an over-stress and the number of cycles at which a crack will form in a smooth test bar. We do not know how such data would be modified in practice by the size, shape, and surface condition of the steel. Most important of all, would be a knowledge of how high a stress could be used without causing a crack to spread.

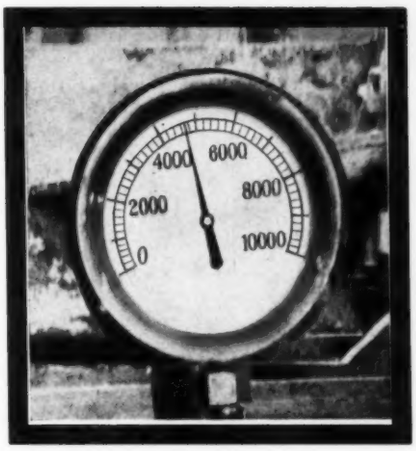
If the writer has succeeded in showing that the mechanical properties of steel, as determined in laboratory tests, are not absolute standards of metal performance in service, the main purpose of this article has been accomplished. *A better knowledge of the relative reliability of different steels is important.* How nearly may we expect one bar of a given steel to be just like another bar of the same type? When these bars are forged, or machined, or heat-treated, how nearly will they behave alike: (For example, compare the spread of elastic-limit values as shown in Fig. 1.) If some steels have a much narrower spread than others, the steel user should know it.

HIGHLIGHTS OF THE DISCUSSION

R. G. Hamaker, Reed Roller Bit Company: This paper serves to call attention to the tendency to use as a basis of design large amounts of data published with different viewpoints in mind. I do not believe that the author means to discredit laboratory testing, but in a logical manner to call attention to the lack of agreement between different laboratories as well as actual field experience.

Steel, of course, is a very complex substance with small amounts of impurities (a few .01% sometimes influencing it as much as 3% or 4% of others). To gain a knowledge of just how each alloy or impurity affects a piece of metal has caused research that requires volumes to review. But there are some certainties that may be gained from making use of standard tests.

To an engineer of tests operating in



Close-up photograph of gauge shows 4700 lb. pressure

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his own laboratory, a large number of factors are taken into consideration, that may only confuse the designer, but under some circumstances may be the determining factor in the choice of steel. The uniformity of even a clean steel is always open to question. Of course, it is impossible to examine all the cross section of all pieces of steel, and this must be controlled by uniformity of manufacturing methods from the very start. Even in this case, individual tests may be far from representative of the actual values of the steel. To overcome this requires, in the case of some steels, considerable study that methods of sampling may be correctly employed. Differences of chemical analysis necessary to make commercial steels may in some cases be too great to make an average figure representative. Follow this by deep-etch testing and microscopic analysis and two pieces of the same analysis steel may be in no agreement.

A factor greatly influencing the physical properties of steel that has been developed since a large amount of existing data were published is grain size and its influence on physical properties and hardenability. Other factors equally as important may yet be discovered.

The practice of reporting steels with a certain heat treatment may be far from accurate, as tests show steels of almost identical chemical and microscopic characteristics may vary widely in their hardenability. The comparison of hardness values with microstructures affords a check of uniformity. Due to the fact that the mass effect is not thoroughly understood, interpolations are difficult to make from standard test specimens to actual product. The value of physical testing equipment to be able to make comparisons between these standard tests and tests taken from actual sections of the product is high. A close control of the processes of manufacture and preserving it in a uniform manner is of great value in maintaining a constant relation.

The accessibility of a well-equipped laboratory to the designing engineer often saves expensive trial and error methods regarding what may be expected of products designed for service, and such data as presented by Mr. Clapp on notch testing are of great value. Standardized tests will serve to show uniformity of product.

Of course, in the last analysis the proof of the whole thing is how the product behaves in the field, and here a constant study by field and production engineers may bring to light places where corrosion may be a determining factor; torsion where it was thought tension was the greatest; unavoidable tool marks in vital parts; wear resistance on a number of other things that sufficient study on the part of manufacturers and users of equipment may help to solve.

In conclusion, it must be realized that steel as we have it today is not an exact material, but instead a something that can be likened to bread or pastry dough, the constituents of which vary from batch to batch. With the increasing demand for greater and improved uiformity in steel, a narrowing down in the specifications to the steel manufacturer is called for. This not only means narrowed ranges of constituent allowances, but also closer and more exacting controls during the process of manufacture; also, closer and more exacting controls will have to be exercised in the processing of the steel; by processing the steel is meant such operations as forging and heat-treating.

In the processing of the steel we are too prone to assume that records received from the forging furnaces or from the heat-treating furnaces are correct. For example, are we always sure that the temperatures recorded from these furnaces are also the temperatures or rather a known relative temperature of the piece that was heated? The condition of the quench, and the application of the quench to the heated piece are variables that must be controlled to within closer limits.

The probabilities are that there will be many times the improvement in manufacturing and in processing steel within the next ten years that there has been within the past ten years.

In the use or handling of products made of steel, there must likewise be made vast improvements. The requirements of steel must become better known, and much more intelligent determination of the causes of failures are overdue.

H. W. Fletcher, Hughes Tool Company: The importance of the considerations brought out in Prof. Clapp's paper cannot be too highly stressed. Engineering answers, in general, partake *not* of the accuracy of the mathematics by means of which the answer is reached, but of the *inaccuracy* of the *assumptions* (as to the physical facts involved and their mutual relations) on which the mathematical development is based. The judgment of the designer is of far more importance in reaching a successful conclusion than is his ability as a computor, for reasons which follow.

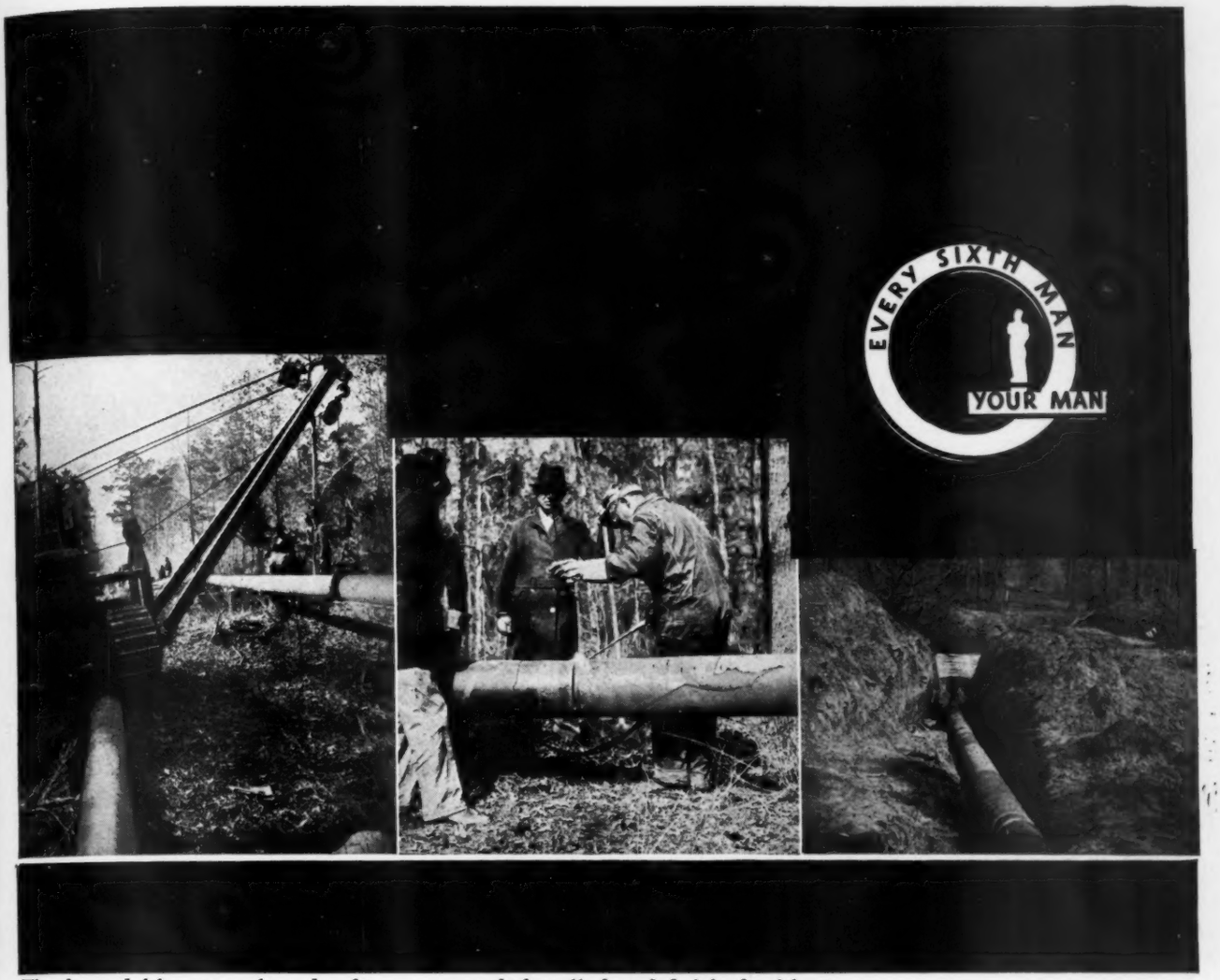
Prof. Clapp has stated that the principal difficulty arises from the fact that "we do not as yet know why metals fail for any condition of service." In the lack of that knowledge it is obviously impossible to set up a *simple* system for unit strength for use in design.

A somewhat parallel though much simpler case exists in the matter of gaging taper screw threads. Units of measurement are definitely established, well understood, and commercially reproducible. The production of interchangeable parts based on the direct measurement of lengths and diameters has become a common-place. When, however, it becomes necessary to measure a tapered screw thread under commercial conditions it is done with a plug and ring gage which must "measure" *simultaneously* five thread elements, and which consequently measures none of them. Measurements of so simple a thing as length has become vastly complicated by requiring only that dimensions be handled in mutually interrelated groups.

On the other hand this gage system in the hands of experts familiar with its shortcomings will produce satisfactory commercial work in spite of obvious technical defects in the system.

Standardized physical tests have been developed to yield *some* information regarding the behavior of materials under load of one kind or another in spite of our ignorance of the mechanism of failure. To permit comparison of data from various sources, it has been found necessary to standardize the tests to a very high degree. The test pieces must be of certain size and shape with a specified surface finish; the testing machine must be of a certain type, the temperature, rate of loading, etc., be as specified. Obviously the conditions of test do not even approximate the conditions of service and the effect of the difference may often result in a realized value only one-half or one-third of that predicted, much less than that amount in extreme cases, and certainly not a negligible variation.

Here again we use this admittedly unsatisfactory system of units for lack of a better one, and largely, as Prof. Clapp has pointed out, because our ignorance of the actual manner of failure makes it impossible to set up what might be called fundamental units. The slack is taken up by making an arbitrary allowance to cover incompleteness and inaccuracies in the equations as well as variations in the materials and lack of correspondence between test conditions and service conditions. The so-called factor of safety that expresses this allowance is based on observed results with full size structures, and the actual margin of safety resulting depends on the amount of information available as to



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the performance of similar structures under similar conditions.

When we consider that we require strength, toughness, ductility, hardness, resistance to impact and to corrosion in varying degrees depending on the application under consideration, and that each of these qualities is measured in units that are functions not only of the material tested, but of the conditions of the test itself, the impossibility of predicting the performance of any given untried combination in a particular application with any great accuracy is apparent. We can reason qualitatively by analogy, but for reliable quantitative results we are driven to actual trial in service, often a long drawn-out and costly process.

Before embarking on such a program, it is only reasonable to investigate the possible advantages to be realized, and to weigh the amount and value of the improvement if attained, against the cost in time, money, and probable failures during development. Here again a decision cannot be reached with mathematical exactness, but must in the last analysis depend largely on "judgment" which in turn is only an expression of opinion based on previous experience. One fact, however, does stand out in such a situation; unless the improvement to be expected is sufficient to be apparent under conditions of commercial service, it is not only unprofitable but unwise to embark on such a program, since there will be no demonstrable gain to offset the risk inevitable in trying a new combination.

Thus when the designer is confronted with data such as Prof. Clapp illustrates, where the spread in properties of different tests of the *same* materials is of the same order or even greater than the differences between tests of *different* materials, he must conclude that the data are indeterminate, and must resort to comparative trials in service, if such trials can be justified, to arrive at a satsfactory solution.

Two Unusual Installations of Cathodic Protection of Pipe Lines[1]

By GEORGE I. RHODES[2]

WHENEVER the cathodic protection of pipe lines requires a large amount of electric current, or the cost of electric current is high, it becomes necessary to minimize the amount of power required to keep the pipe lines suitably negative to the soil in which they are buried. This contribution to today's symposium on the subject of cathodic protection of pipe lines relates to two installations where the waste of electric power has been reduced to a minimum.

The two installations constitute: *a*, that made in 1934 on the lines of the Interstate Natural Gas Company, Inc., in Louisiana between the Monroe gas field and Baton Rouge, Louisiana; and, *b*, that made in 1935 and 1936 on the system owned by the Canadian River Gas Company and the Colorado Interstate Gas Company between the Amarillo gas field in the Texas Panhandle and Denver, Colorado.

The Louisiana installation utilizes purchased electric power, and the Colorado installation utilizes energy generated by the galvanic action between zinc and the pipe line itself. The pipe protected in Louisiana is coated with a hot enamel consisting of a filled asphalt-pitch mixture in rather bad condition. The pipe line protected in Colorado is a bare line, the original cold bituminous paint having completely disappeared. Both installations differ from the ordinary installation of cathodic protection in that the anodes or ground beds are fairly uniformly distributed or spread out along the pipe line instead of being concentrated at points in the general vicinity of the rectifiers or electric generators furnishing the current required for protection.

The Louisiana Installation. The installation made on the system of the Interstate Natural Gas Company, Inc., in Louisiana is summarized as to extent by the following:

No. and Size of Pipes	Miles of Right-of-way	Miles of Pipe	Miles of 22-in. Pipe Equivalent
1—22-in. O. D.	20.92	20.92	20.92
2—22-in. O. D.	12.70	25.40	25.40
4—12¾-in. to 14-in. O. D.	8.21	32.84	19.40
Total	41.83	79.16	65.72

All of the 22-in. pipe in this installation was Dresser-coupled with pipe joints of single random-length and hot-filled asphalt-pitch enamel without wrapper. The 12¾-in. pipe was screw-coupled and similarly coated. The 14-in. pipe was welded and coated with pitch and tar-paper wrapper. Bonds consisting of ⅛-in. by 2-in. strip copper were welded around all Dresser couplings, thus making the line electrically-continuous from end to end. The conductivity of the bonds was much less than that of the pipe, but the bonded pipe line had electrical conductance equal to about 60 percent of that which would have resulted had the line been welded.

Experimental Work in Louisiana. Experimental work indicated that there would be great difficulty in maintaining a minimum protection of 0.4 volt, and that heavy currents would be required unless means were taken to hold down the protective voltage in the vicinity of the sources of power.

A temporary installation of cathodic protection to a 5-mile section was made, which was placed in operation early in January, 1933, using the usual concentrated ground beds, and was continued in operation until the middle of June, 1934. As a result of the performance of the temporary installation, it was found that from 25 amp. to 50 amp. per mile of 22-in. pipe would be required to maintain the pipe at all points 0.4 volt, or more, negative to the soil in its immediate vicinity; and that in order to keep the currents down even to such seemingly high values, it would be necessary to avoid the usual excessive protective voltage in the vicinity of the power sources. A means for maintaining this uniform protective current was developed.

Coke-Carbon Anodes. The installation as actually made was designed to provide a protective current of 50 amp. per mile in most sections. The ampere drainage capacity largely controls the number of anodes. Approximately 3300 carbon anodes were installed, more or less uniformly distributed along any particular section of the lines. Where there was but a single line, the anodes in general were all placed on the same side of the right-of-way; but where there was more than one pipe line, the anodes

[1]Report for Presentation at Meeting of Committee on Pipe Lines, before Seventeenth Annual Meeting, American Petroleum Institute, Chicago, Illinois, November 12, 1936.

[2]Ford, Bacon and Davis, Inc., New York, New York.

were distributed on both sides of the right-of-way.

The anodes as installed are shown in Fig. 1. It was found necessary to impregnate against moisture at least six in. of the connection end of the carbon rod. This was accomplished by forcing melted paraffin into the rod internally through the holes drilled to provide the wire connections until that paraffin began to ooze from the surface of the rod. Upon cooling, the rod was found to be satisfactorily moisture-proof. Unless such precautions are taken, the galvanic action between carbon, copper, and solder results in corrosion which may destroy the electrical connection within a few months.

The coke filling about the carbon rod was found to be necessary, because carbon as an anode in the ground is burned to carbon dioxide by the released oxygen at the rate of four lb. or five lb. of carbon per year per ampere. The coke filling around the carbon rod protects the rod from this cold combustion, but is itself consumed. It is particularly important that the entire carbon rod be surrounded with crushed coke, which in general is carried to the surface of the ground. It is expected that, as the coke is consumed, it will gradually settle in the hole, carrying the carbon rod with it. It is probable that the coke will require replenishing every few years—although approximately 80 lb. are required for each anode, which should last from 15 to 20 years of maximum service.

Coke-carbon anodes as installed were found to have an average resistance in low wet ground of about two ohms per anode, and in higher ground about four ohms. In forcing current into the ground through these anodes, a back voltage of about 1.6 volts is encountered, so that the total voltage required for any anode is 1.6 volts in excess of the resistance drop as ordinarily computed.

Anode Wiring—Adjusting Resistances. The carbon anodes adjacent to each telephone pole were connected together and, through a riser on the pole, were connected to an overhead positive feeder which, as installed, was a 1/0 solid bare copper wire extending throughout the entire 42 miles of right-of-way to which protection was applied. This 1/0 copper feeder was supported on the telephone poles by brackets and telephone insulators.

Between the riser at each telephone pole and the positive feeder there was installed, in each instance, an adjustable anode group resistance. This resistance was installed for the prime purpose of adjusting the protective voltage of the pipe line at each telephone pole to that voltage which is required. The need for the resistance arises: 1, from the fact that it is impossible to determine precisely how many anodes are required at any particular location; and, 2, because of the fact that the available voltage varies, depending on distance from the power source.

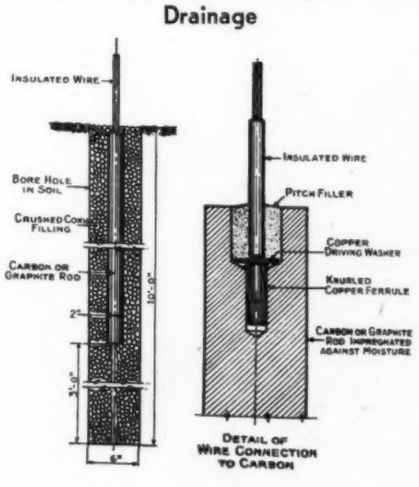
The entire installation involved approximately 42 miles of positive feeder wire supported on the telephone poles and approximately 50 miles of No. 10 copper-covered wire without braid providing connections between the overhead positive feeder and the carbon anodes. From the base of the pole to the anodes the wire was buried in the ground, up to 18 in. if required by cultivation of the soil on the right-of-way. Probably 90 percent of this wire was plowed into the ground.

Rectifiers. At 73 locations along the 42 miles of right-of-way rectifiers were installed. Approximately two-thirds of the rectifiers were 50-amp. units, and the other one-third were 25-amp. half-units which differed from the 50-amp. units only by having had left out of them one of the two units or boxes of rectifier stacks. The rectifiers were of the copper-oxide type.

All the transformers are suitable for 50-amp. rectifiers. Each transformer is protected with the usual fused cut-outs and a lightning arrester.

Power Circuit. In order to supply power to the rectifiers a single-phase 2300-volt circuit made up of two No. 6 bare copper wires was installed on the line of telephone poles which extended on the right-of-way throughout the entire distance involved. Six-pin cross-arms were already in place. The telephone wires were moved to one end of the cross-arm, and the power wires installed on the other end of the cross-arm.

Fig. 1. Coke Anode for Pipe-Line Drainage



Voltage Required for Protection. As already pointed out, this system was designed to take care of upwards of 50 amp. per mile with the pipe maintained at 0.4 volt negative to the soil in its immediate vicinity. This corresponds approximately to 0.5 volt between the pipe and the soil at the edge of the right-of-way. While the construction was under way, some research work was carried out in the laboratory to determine what voltage between pipe and soil was necessary to insure the maximum protection against corrosion. It was found that 0.25 volt between the pipe and the contacting soil was ample to give full protection.

In order to determine in the field the effectiveness of the protection applied to the pipe line, special portable instruments were developed. Exploring electrodes of pipe steel were made as shown in Fig. 2, and the voltage between an electrode in electrical contact with the pipe and an electrode with insulated top resting on the pipe were measured by a potentiometer voltmeter. When by means of the rheostats the galvanometer is made to read zero, the voltmeter reads true voltage without drawing any current; hence, relatively small soil electrodes can be used without error due to their resistance. The actual instrument used combined the voltmeter, the galvanometer, the control rheostats, and the battery in a case but little bigger than that of a portable voltmeter.

Current Vs. Back Voltage. With such measuring instruments, determination was made of the relation between current and average voltage of about 2000 ft. of pipe line with the system of cathodic protection as actually installed. The pipe had been protected at an average of 0.33 to 0.35 volt for about two months. Immediately after making the voltage readings as found, the current was increased to several times the current as found; and, after 48 hours, voltages again were measured, which averaged from 0.4 to 0.45 volt. Following the high-current readings the current was again reduced to a fraction of the current as originally found; and, after 48 hours, the voltage was again determined, and found to be from 0.28 to 0.30 volt.

The currents and voltages were separately determined for somewhat less than one-half of the test section which is in low ground typical of that frequently flooded on the system, and for the remainder which is in higher ground bordering the low ground—which is occasionally flooded. Voltages were determined at and midway between individual anode locations.

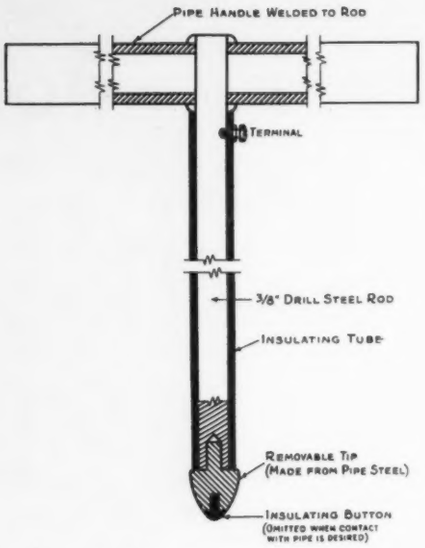

PIPE HANDLE WELDED TO ROD
TERMINAL
3/8" DRILL STEEL ROD
INSULATING TUBE
REMOVABLE TIP (MADE FROM PIPE STEEL)
INSULATING BUTTON (OMITTED WHEN CONTACT WITH PIPE IS DESIRED)

Fig. 2. Field-Exploring Electrode

The results of these tests, showing the relation between amperes per mile of pipe and the voltage between the pipe and the contacting soil, are shown in Fig. 3. Separate solid lines show the current requirements of pipe in low ground and in higher ground. There are also shown, by dotted lines in the same illustration, the computed current requirements of bare 22-in. pipe after the current had been flowing one hour, for 100 hours and for 1000 hours. These curves were computed from laboratory work on small strip specimens of steel in soil from the most corrosive section of the pipe line and thoroughly saturated with moisture.

It will be noted that while the current requirements of bare pipe determined from laboratory tests vary approximately as the cube of the voltage, the current requirements measured in the field vary as a high power of the voltage. In other words, a given percent change in voltage results in a larger percent change of current in the field than in the laboratory. This is due unquestionably to the time element. It is reasonable to assume that the conditions determined after two months of operation were stable. Had the high currents been allowed to flow for periods greater than 48 hours, the voltages would have built up perhaps 0.05 volt more; and had the low currents been allowed to flow for a longer period, the voltage would have fallen off to a greater extent. The field results are, therefore, reasonably in accord with the laboratory results.

The difference in scales of the laboratory and field curves should be particularly noted. The laboratory currents which are based on bare pipe are of the order of ten times as great as the currents observed in the field on coated pipe. It is clearly indicated, therefore, that the coated pipe behaves very much as though 90 percent or more of the coating was a perfect insulator and the other ten percent or less had disappeared completely, leaving the pipe bare in that same proportion of its total area.

Variations in Conditions. Fig. 3 is also a confirmation of the preliminary tests which indicated that, if the pipe is maintained approximately 0.4 volt negative to the soil in its immediate vicinity, upwards of 50 amp. of line per mile will be required. Laboratory tests, however, proved that 0.25 volt was sufficient to insure adequate protection; and, accordingly, the resistances installed between the feeder wire and the groups of carbon anodes at the telephone poles were adjusted until throughout the system the protective voltage at the pipe was rather less than 0.25 volt, with an average current requirement of approximately 8.6 amp. per mile of 22-in. pipe or its equivalent area in smaller pipes. Stabilizing the protective voltage to a minimum of 0.25 volt, it was estimated, would result in an average protective voltage of 0.275 volt with an increased current of about 12 amp. per mile of 22-in. pipe or equivalent.

The current requirements along the right-of-way, in terms of 0.275 volt average protection, were found to vary within wide limits: from a minimum of less than 3 amp. per mile with a single 22-in. line to a maximum of more than 150 amp. per mile of right-of-way in the case of four 12¾-in. to 14-in. lines.

Cost. The cost of this installation as a whole is of little general interest and value to others who have similar problems to solve. Nevertheless, the unit costs of doing the work of the various classes are of considerable interest, because they will apply with proper adjustment for local conditions to a system designed for any other current requirements. These costs, including supervision and equipment charges, as well as labor and material, were approximately as follows:

Coke carbon anodes, $5.00 each.

Anode connection wires underground and attached to poles, $4.50 per 100 feet.

1/0 d-c. feeder wire, $390.00 per mile.

Power circuit on existing telephone poles, $275.00 per mile.

Coupling bonds, $3.65 each.

50-amp. rectifier units with appurtenances, $275.00 each.

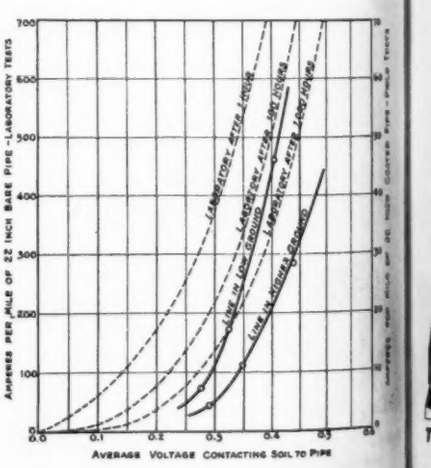
25-amp. rectifier units with appurtenances for later enlargement to 50-amp., $200.00 each.

If there are no existing telephone poles on the right-of-way suitable to support the wires, then the costs naturally must include the cost of such a pole line. If power can be purchased at all rectifier locations, naturally the power circuit can be omitted.

The Colorado Installation. In the spring of 1935 certain of the lines of the Colorado Interstate Gas Company running through irrigated lands in the Arkansas River valley near LaJunta, Colorado, began to develop leaks so badly that several miles of 6-in. and 8-in. bare line were ready for replacement. Much of this line ran through cultivated fields where there were no telephone-pole lines nor could permission be obtained for their installation. Other sections were on highway rights-of-way paralleling heavy Bell Telephone pole lines of many circuits. Cathodic protection using rectifiers was undesirable along the highway because of possible serious telephone disturbances, and it would have been expensive in the irrigated fields on account of the fact that power lines as well as low-voltage direct-current lines must necessarily be placed under ground.

Wind-mill generators were seriously considered; but, the wind velocity being less than seven miles per hour for half the time, it was then found impossible with any commercially-obtainable wind mill to generate the required amount of power for a sufficiently large proportion of the time to secure protection. The estimated current requirements for a properly-installed system were about 30 amp. per mile for

Fig. 3. Current vs. Back Voltage. Field and Laboratory Tests. Typical 22-in. Line in Louisiana


AMPERES PER MILE OF 22 INCH BARE PIPE - LABORATORY TESTS
AVERAGE VOLTAGE CONTACTING SOIL TO PIPE
LABORATORY ACTIVE 1 HOUR
LABORATORY ACTIVE 100 HOURS
LINE IN LOW GROUND
LABORATORY ACTIVE 1000 HOURS
LINE IN HIGHER GROUND

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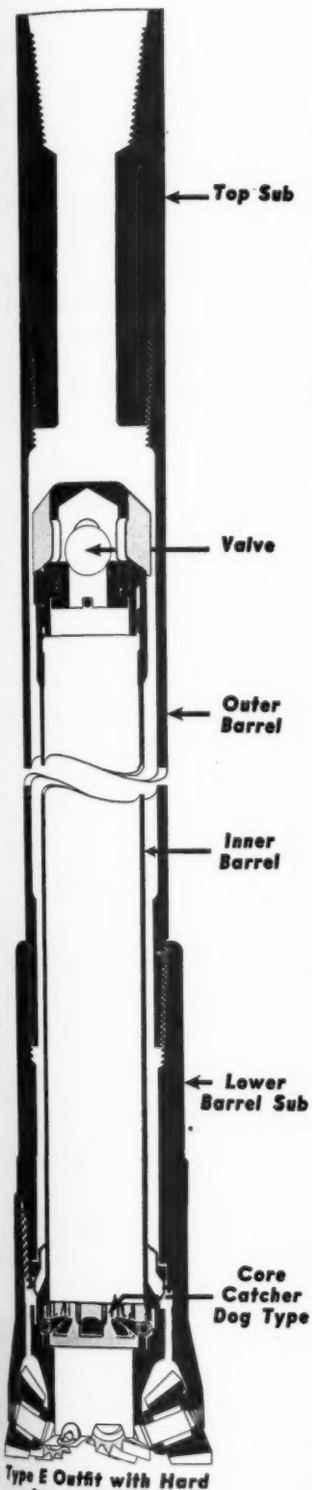
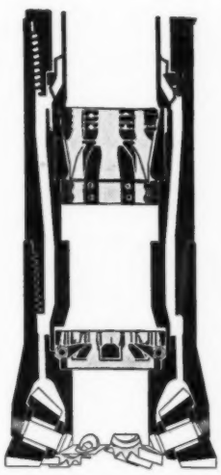
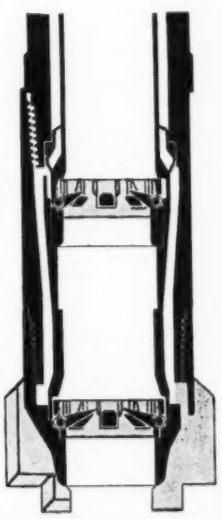


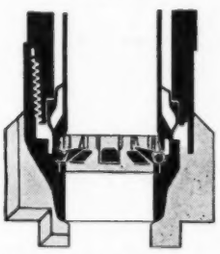
Type E Outfit with Hard formation head



Equipped with Hard Formation Head, Dog Type and Slip Type Catcher



Soft Formation Head and Double Dog Type Core Catcher arrangement



With one Dog Type Catcher in the Soft Formation Head

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The illustrations at left show how *one* Core Barrel can be equipped with various combinations to provide a "tailor made" outfit to meet every requirement. At right and below are pictured the three types of core catchers and two types of heads.

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8-in. bare pipe and 22 amp. per mile for 6-in. bare pipe. With half-time operation, higher currents would have been required.

Experimental Installation of Zinc. An experimental zinc installation in Colorado was applied to approximately two miles of 6-in. and 8-in. bare pipe divided between six locations typical of the worst conditions on the line found to require protection or reconditioning. The installation was made very much like that in Louisiana, except that there were, of course, no rectifiers. Zinc rods approximately 1 in. sq. in cross-section and 4 ft. long were used as anodes in place of carbon rods.

Zinc containing less than 0.01 percent of lead and cadmium was used. The low content of lead and cadmium is apparently necessary. Ordinarily, commercial zinc contains so much of these impurities that, as it corrodes in galvanic action, the lead and cadmium are left behind as a coating on the zinc. The lead-iron galvanic couple is of reverse polarity compared with the zinc-iron couple, and of approximately the same voltage. Obviously, if any considerable portion of the zinc surface is covered with lead, the net effective working voltage between the anode and the iron becomes reduced—and may, in extreme cases, even be reversed.

The 1-in. square zinc anodes 4 ft. long were installed at approximately 10-ft. intervals along the 8-in. bare pipe line, and about 5 ft. distant. An interval of 12 ft. between rods was used in the case of 6-in. line. These rods were connected to a No. 10 rubber-covered copper wire without braid which was plowed into the ground, and in turn connected to the pipe at intervals of about 100 feet.

In this experimental installation it was found that the average current generated by 1-in. sq. zinc bars was approximately 0.025 amp. The 8-in. pipe with approximately 520 bars per mile developed a current of about 13 amp. per mile, which is about 40 percent that thought to be required when power is used. With ground sufficiently moist to secure accurate voltage readings, the average voltage between pipe and soil was about 0.125 volt. In drier soils, which are only intermittently irrigated, voltage measurements were difficult to secure. In many cases it was not possible, as indicated by these measurements, to reduce the potential of the pipe to a negative value. Before protection was applied, the pipe was about 0.2 volt positive to the soil.

Before the zinc rods were connected to the pipe, the voltage from clean steel to the zinc was about 0.4 volt, the steel being positive; and the voltage from the corroded pipe to the zinc was about 0.6 volt. After the zinc rods were connected to the pipe, the flow of current reduced the positive value of the pipe-zinc voltage, until after a few weeks it became less than 0.3 volt in wet soils and more in dry soils.

The test installation stopped the development of leaks, and led to a decision to make a much more extensive installation in 1936 and to put the experimental installation into permanent condition.

Colorado Costs. The average cost of the 1936 work in Colorado was approximately $1.41 per rod for the zinc anodes, and $1.75 each for their installation.

The cost per anode was found to vary from $3.08 per rod (with 460 per mile) to $3.21 per rod (with 355 per mile). These costs correspond to $340 per mile plus $2.62 per anode. All development costs, equipment charges, tools, and overheads are included in these costs, as well as labor and materials. Much of the development cost could be avoided with later installation at a saving which should bring the cost down to $2.40 per rod. At the costs actually experienced, however, the cost of applying 20-year protection by the use of zinc is approximately as follows:

Nominal Pipe Size (Inches)	Zinc Anodes Per Mile	Cost Per Mile
4	240	$ 970
6	350	1,260
8	460	1,550
10	570	1,830
12	680	2,120

Practical Result. The experimental Colorado installation now in permanent form has been in service about 16 months; the 1936 installation, from two to four months. The lines have been recently uncovered and inspected by the operating staff. With the exception of one point, the installation was reported to be protecting the pipe. In the one case where protection did not seem to be effective, broken or wrong connections are thought to be the cause.

PAUL G. EXLINE

New Apparatus for Securing and Examining Sub-Surface Samples of Oil[1]

By PAUL G. EXLINE[2]

THIS paper describes a sub-surface sampler and the apparatus used in analyzing the samples of reservoir fluid obtained with it. Basically, the function of a sampler is to obtain a sample of reservoir fluid as it exists at the sampling point, and to retain this sample intact until the tests can be made.

The equipment consists of the sampler used both for obtaining the sample and as the container during its examination, a dead-weight tester for measuring pressures, a heater jacket for maintaining the samples at a constant temperature during the tests, a gas

[1] Abstract of paper presented at seventeenth annual meeting, American Petroleum Institute, Chicago, November 12, 1936.

[2] Gulf Research and Development Co., Harmarville, Pennsylvania.

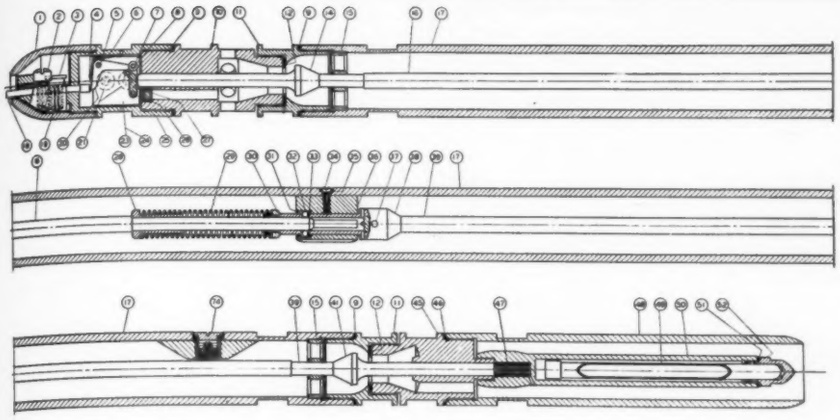


Fig. 1. Sectional view of Sampler (valves locked open)

meter for measuring gas volumes, a mercury pump for changing the effective volume of the sample chamber by introducing mercury under pressure, together with several devices for attaching these to the sampler.

The sampler, Fig. 1, consists of a tubular chamber open at both ends with means for forcibly closing the ends of the chamber, thus trapping a sample of the fluid. The total length of the device is 61 in., with a diameter of 1¾ in., which permits it to be lowered into tubing as small as 2 inches. The internal passages are designed to offer minimum obstruction to the flow of oil through it; so that, as it is lowered into a fluid column with the valves open, it passes through the fluid without carrying any along to a lower level. The sample chamber is a single tube (17) 42 in. in length and 1⅜ in. in inside diameter. This chamber is closed when the knife-edged valves (14 and 41) are thrust against the fiber valve seats (12). The valve seats are clamped against the valve housings (11) by the two valve guides (10 and 45), and are replaced by new ones after each run in order to insure perfect sealing. The upper valve (14) is prevented from closing by the valve stop (27) which is held in place by the bell crank (20) until the trigger (18) is depressed. The upper valve is forcibly held against the valve stop by the upper push rod (16) which is acted on by the spring (29). The lower valve (41) is held against the lower push rod (39) by the dash pot spring (47). The spring (29) acts against the locking sleeve (38) attached to this rod, tending to force it downward. Motion is prevented by the walls of the two holes in the sleeve resting against the two balls (32) which are wedged between the annular insert (33) in the spider (36) and a shoulder near the end of the upper push rod.

A diaphragm is utilized in order to measure the pressure in the sampler without change of volume or possibility of loss of any of the sample. This construction is shown in Fig. 2. A steel disc of 0.002 in. thickness by ½ in. in diameter is clamped at the edges against a flat bakelite surface. The sampler pressure against the free surface of the diaphragm, which is chromium-plated on both sides to prevent corrosion, forces the diaphragm against the bakelite surface.

A steel conductor, whose end is lapped flush with the surface of the bakelite, makes electrical contact with the disc when pressures on both sides of the disc are equal. An attachment is supplied for applying pressure to the outside surface of the disc until contact is just broken, as indicated by a high-resistance voltmeter in the electrical circuit. A small hand pump and pressure gage are provided for making an approximate determination of the sampler pressure immediately upon its withdrawal from the well.

A bleeder head enables one of the sampler valves to be opened without loss of fluid. It has a central push rod acting through a packing gland for forcing the lower valve open. Two needle valves provide connections to the mercury pump and the separator. Fig. 3 shows the bleeder head assembled on a sampler.

A heater jacket maintains the sampler at the desired temperature during the analysis.

The cross-section of the mercury pump is shown in Fig. 4.

Gas-volume measurements are made by use of a meter of special construction.

The sampler pressures are measured by means of a dead-weight tester.

Determination of the sampler volume is a simple matter consisting of weighing when empty and when full of mercury, and calculating the volume from the weight difference. Care must be taken to insure that no air is trapped in the sampler, and that there is no mercury outside of the two valve seats. The volumes of five samplers constructed average about 910 cc.

When the sampler, which is run on a Halliburton line, has been lowered to the desired depth in the well, it is held stationary, and a messenger released. The messenger strikes the cap on the sampler, after depressing a trigger. The upper valve is then pushed shut by a spring with a force of approximately 50 pounds. This is sufficient to cut a groove about $\frac{1}{32}$ in. deep all around the valve seat, thus affording a perfect seal. In closing the upper valve, the upper push rod moves about ¼ in., bringing the small-diameter end of the push rod opposite two balls. This removes the wedging action, and the lower push rod can then be forced downward by the spring. The lower valve is pushed into the lower seat, thus sealing in the contents of the sampling chamber. To avoid a sudden decrease in pressure inside the sampler while the lower valve is closing, a dash pot is provided in the thermometer housing to slow down its action. After the sampler has been withdrawn from the well, the pressure is checked—using a pressure attachment and small hand pump. In case of failure to ob-

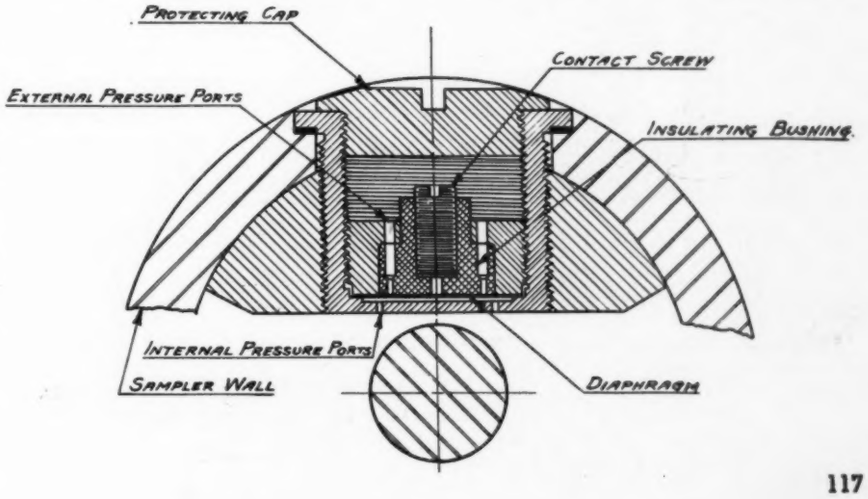
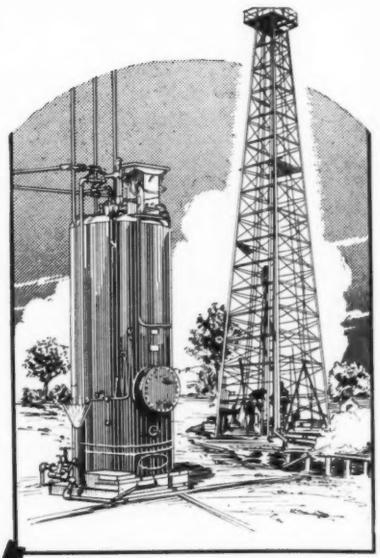


Fig. 2. Pressure-balancing diaphragm for measuring sampler pressures



Analyze Your Treating Costs TO INSURE GENUINE ECONOMY

The usual method of computing dehydration costs is in cents per barrel. However, this procedure can be very misleading unless correctly applied. A recent example clearly illustrates this possibility.

One cent per barrel was given as the cost of treating the production of a certain lease by a well known method. An analysis by Petreco engineers disclosed that less than half the crude produced was being dehydrated, while the total monthly cost of treating was applied to the total production of the lease; with the result that the true cost per barrel was more than double the amount estimated, as follows:

	Method Used	Correct Method
Total Production Of Lease	1,000 bbls.	1,000 bbls.
Production Dehydrated	500 "	500 "
Total Cost Of Treating	$10.00	$10.00
Cost Per Barrel	.01*	.02**

* Figured on total production of 1,000 bbls. when less than half the production was dehydrated. ** Figured on actual volume of production dehydrated.

To insure highest economy, producers should carefully analyze treating costs and apply these costs precisely to the volume of crude dehydrated. Petreco engineers are available for assistance in this respect at all times, without obligation.

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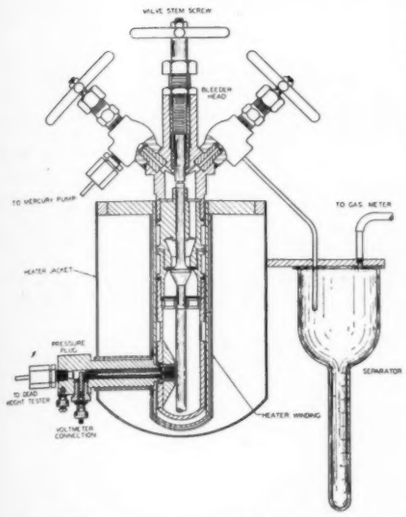

Fig. 3. Sampler assembly in heater jacket

tain a sample due to improper setting of the sampler or from other causes, it is a matter of a few minutes to replace the valve seats with new ones and make another run. If the pressure measurement indicates that a good sample has been obtained, the temperature indicated by the maximum-registering thermometer is recorded, and the sampler is taken to the field laboratory for further examination.

In preparing the sampler for a run the bleeder head is screwed on the lower valve guide, and the sampler assembled in the heater jacket as shown in Fig. 3. Connections are made to the dead-weight tester, mercury pump, and gas meter. Mercury is pumped into the head until the entire space above the valve is filled and a few drops have run over into the separator. The valve to the separator is then closed, the heater jacket inverted, and weights piled on the dead-weight tester until the voltmeter indicates that contact at the diaphragm is broken. Mercury is then pumped into the bleeder head until the voltmeter needle indicates a rise in pressure showing that some mercury has been forced past the valves. The push rod is then screwed in until it stops opening the valve wide. The mercury pump is then reversed, and mercury withdrawn from the sampler until the pressure falls to its initial value. Since the pressure in the sampler has been unchanged during this operation, there has been no change in volume. If the sampler is full of fluid with no free gas present, it is extremely sensitive to volume changes, 0.01 cc. giving a pressure change of 1 lb. to 2 lb. per sq. inch. The sampler is then rotated back to its initial position, which causes the mercury to fall down through the fluid, displacing some of the fluid into the head—although the space occupied by the fluid is unchanged. Three or four cubic centimeters of mercury are pumped into the sampler one at a time, with the mercury-pump reading and the pressures following each injection being recorded. This information is used in determining the compressibility of the oil at the pressure existing. The needle valve for the separator is then cracked slightly to permit gas to come out of solution. The gas is bled off very slowly, and occasionally its flow is interrupted while the sample is stirred. Excellent contact is obtained during stirring, so that equilibrium conditions are reached in a few seconds. With each reversal the mercury falls down through the fluid in small drops, while the gas travels upward through the fluid column. It has been observed that five or six complete reversals will suffice to obtain equilibrium conditions. After the first sample of gas has been withdrawn (usually 3 to 5 per cent of what is estimated to be the total amount) the temperature of the gas, its volume, the barometric pressure, and the volume of residual oil in the separator are recorded. A small quantity of mercury is added to the sampler, and the pressure recorded after thorough stirring. This is repeated until the large increase of pressure per cubic centimeter of mercury added shows that all the free gas in the sampler has been put into solution. If the volume of mercury introduced is plotted against the ensuing pressures, a curve like that shown in Fig. 5 will be obtained. The point of intersection represents the pressure at which all the gas present was just in solution in all the oil present. A slight decrease in pressure would have permitted free gas to break out, while an increase in pressure would result in undersaturation. By subtracting the mercury volume corresponding to this point from the total sampler volume, the volume occupied by the sampler will be obtained.

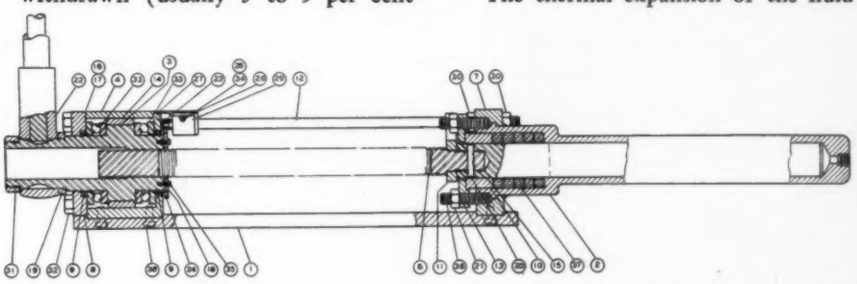

Fig. 4. Mercury-pump section

Fig. 5. Saturating curve

All gas bled off subsequent to this point is measured, as well as the residual oil resulting from this sampler. This information is used in determining the solubility of the gas in the oil at this pressure and the shrinkage of the oil. The slope of the straight line above the saturation point on the graph is proportional to the compressibility of the fluid. Following this, a second small quantity of gas is removed in the same manner as before, and the remaining sample is again resaturated. This process is repeated in steps until all gas has been removed from the sample.

With the valve to the separator wide open, mercury is then pumped into the sampler until oil begins to come out of the sampler. The total residual oil is then given by the sum of all the quantities trapped in the separator plus the difference between the sampler volume and the total volume of mercury pumped into the sampler.

The thermal expansion of the fluid can be measured at any pressure by changing the thermostat setting, thus changing the temperature by a desired amount and maintaining the pressure at a constant value by adding or removing mercury from the sampler.

If free gas is present to a considerable extent, it is inconceivable that a sample could be obtained that would contain the same proportions of gas and oil that existed in the well. There is good evidence that true samples of a single-phase fluid can be obtained. The equipment is capable of being set up in a field laboratory, making it possible to obtain and examine a large number of samples in a relatively short time.

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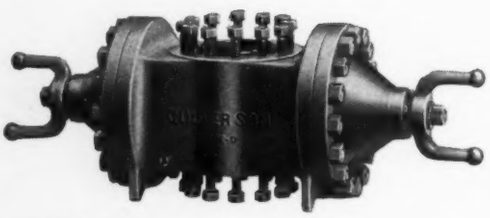

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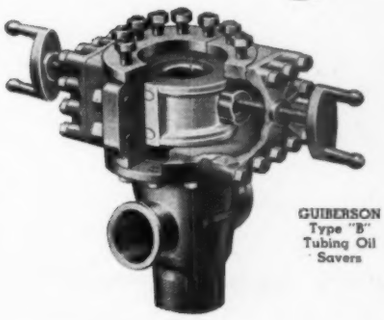

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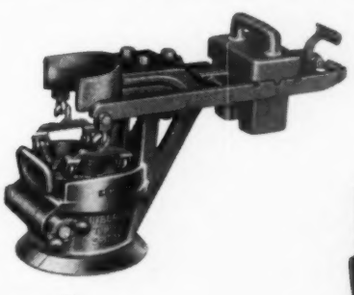

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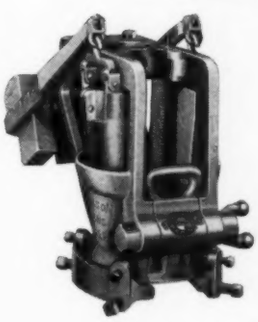

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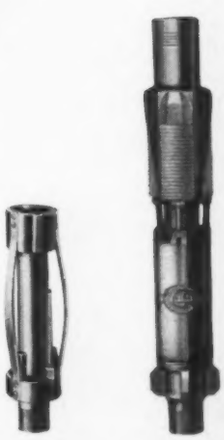

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Quantitative Determination of the Connate-Water Content of Oil Sands[1]

By HOWARD C. PYLE[2] and P. H. JONES[3]

THERE is good evidence of the presence of relatively large quantities of connate water in oil sands that produce oil and gas exclusively. One writer attributes the retention of connate water during oil accumulation and later production to greater interfacial tension between the water and the sand grains than that between the oil and the sand grains. This writer further states that the smaller the sand pore, the greater is the proportional amount of retained water. This may account for the absence of oil in porous shales and the relatively high oil saturation of well-sorted and coarse permeable sands.

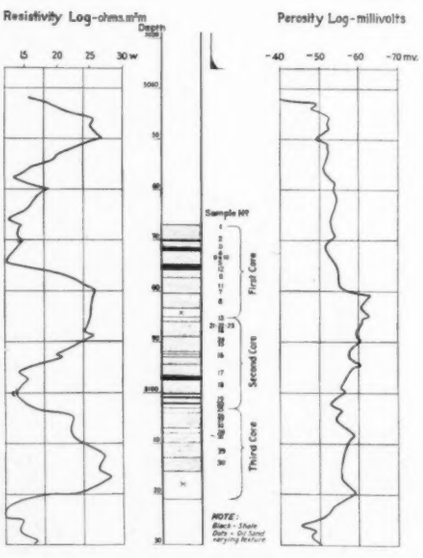
When cores are obtained from wells in which mud is used as a drilling fluid, it is necessary to know the degree of their contamination by water from the mud with which they are in contact. This paper presents a quantitative method of determining the contamination, as well as the connate-water and oil content of sands.

The method used for determining the amount of water in core samples that originated from the drilling mud was to add to the water phase of the mud a tracer material that could be determined quantitatively in the core samples.

By preliminary tests it was found that the dextrose content of mud can be determined by diluting the mud with an equal weight of water and analyzing an aliquot portion of this mixture without centrifuging out a supernatant layer of water.

On test it was demonstrated that dextrose was not absorbed or altered by either the mud or the artificial formation sand, and that dextrose would serve as a satisfactory tracer. It was observed, however, that dextrose mud mixtures fermented on standing, but that octyl alcohol, to the extent of only 0.05 per cent by weight of the water in the mud, prevents this fermentation. The presence of the alcohol does not interfere with the dextrose determinations nor impair the value of the mud.

Fig. 1. Graphic log and Schlumberger record of test interval showing core and sample sequences



The well used for the test was in a field where water-free oil production was known to be available. It had just had a water string of casing successfully cemented above the interval to be cored and sampled.

At the well, dextrose and octyl alcohol were added to fresh mud by batches in the mud-pump suction pit.

With only treated mud in the circulation system the well hole was cleaned to bottom (from 3055 ft. to 3067 ft.), the drill pipe was removed, the drill bit was replaced with a core head and telescoping barrel, and the drill pipe was run into the hole. Mud circulation was established and continued for 30 min., with the core head at bottom, following which an 18-ft. core was taken. Three 18-ft. cores were taken and excellent recovery was attained. A graphic log and Schlumberger record of the interval thus cored are shown in Fig 1. To prevent dilution of the mud, water was not used to wash the drill pipe as it was pulled from the hole between cores, and no make-up water was added at any time.

Cores were sampled (see Fig. 1) as soon as they were withdrawn from the core barrel, and each sample was separately wrapped in waxed paper (lead foil would have been preferable) and sealed in tins. In sampling, care was taken to remove only the mud sheath from about the core and to prevent crushing or otherwise disturbing the friable sands.

In the laboratory the core samples were removed from their tin and paper containers, each sample was broken down to grain size, thoroughly mixed, and divided into two parts. One part (approximately 175 grams) for oil and

[1]Abstract of paper presented at seventeenth annual meeting, American Petroleum Institute, Chicago, November 12, 1936.

[2]Union Oil Co. of California, Los Angeles, California.

[3]Union Oil Co. of California, Wilmington, California.

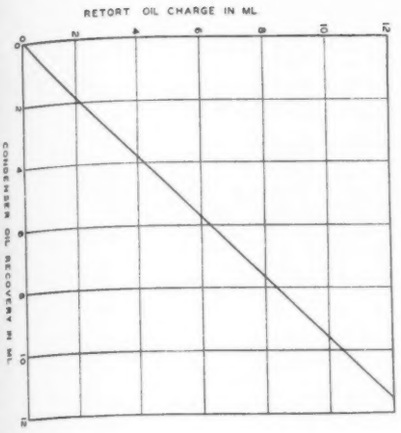


Fig. 2. Retort-oil charges plotted against condenser-oil recoveries

water determinations was placed in an iron retort, and the other (approximately 30 grams) for subsequent dextrose determination was preserved in a pre-weighed, wide-mouth, glass-stoppered bottle. In carrying out these operations the samples were exposed to the atmosphere for about 3 minutes. The iron retorts were heated slowly to a dull red with a gas burner, held at that temperature for 40 min., and then allowed to cool. Calcium-chloride tubes, placed at the top of the retort condensers, prevented any moisture from being drawn into the retort systems on cooling. The condensate from each retort was recovered in a centrifuge tube, which was later centrifuged for 5 min., and its oil and water contents were read to the closest 0.1 ml. After the retort had cooled, the sand was removed from it and weighed.

To determine the extent of oil and water losses in retorting, known quantities of oil, water, and previously-retorted core sand were mixed and retorted. Oil losses were found to vary directly with the initial charged volumes, the losses amounting to approximately 0.4 per ml. per initial 10 ml. Fig 2. shows retort-oil charges plotted against condenser-oil recoveries. Water losses were found to be independent of initial charged volumes, and amounted to 0.2 ml. Also, the recoverable amount of water of crystallization from the average material of the core samples was determined by testing several representative composite samples taken from all the core sands. These composite samples were leached with carbon tetrachloride in Soxhlet extractors for 24 hours, and then dried at 215 deg. fahr. for 4 hours. Water recovered by retorting, after correcting for retort water losses, averaged 0.3 ml. per 100 grams of unretorted oil-free dry sand. Corrections as outlined were applied to the measured oil, and water condensates from the core samples retorted—the corrected quantities being recorded in milliliters per 100 grams of oil-free, dry, unretorted sand.

Samples used for porosity measurements were taken adjacent to those used for analytical determinations. The samples were trimmed to the desired size, leached with carbon tetrachloride in Soxhlet extractors, dried at 215 deg. fahr., and weighed. Bulk volumes were measured by mercury displacement, and effective pore volumes were measured by a Coberly-Stevens hydrogen porosimeter. Porosity values were recorded in percentages as well as in milliliters per 100 grams of oil-free dry sand.

Had there been a possibility that any of the sand pores were isolated by cementing material, it would, of course, have been necessary to measure total porosity rather than effective porosity in order to determine the space available for oil and gas, and water.

Average oil-free dry-sand densities were determined by the pycnometer-tetrachlorethane method, and used to correlate core contents with core pore volumes.

The weights of the samples to be used for dextrose analyses were determined, 25 ml. of distilled water was pipetted into each bottle, and the contents thoroughly agitated. After settling, 10 ml. of supernatant liquid was pipetted into a flask, and its dextrose content determined. The known data available consisted of the weight of the sand plus the oil and water in the sample, the weights of oil and water originally present in the sample, the volume of water added, the volume of the aliquot portion removed for the dextrose determination, and the dextrose content of the portion. From these data the quantity of water found in the sample which had come from the drilling mud was computed and recorded in milliliters per 100 grams of oil-free dry sand.

Results of laboratory tests on 28 samples show that there are no simple relations between sand texture, oil and connate-water content, and degree of core contamination. The relative contamination of sand samples taken at the top and bottom of each core and that of samples taken immediately above and below the shale strata encountered do not indicate the migration of water from the drilling mud for appreciable distances ahead of the core bit. This may have been due largely to the excellence of the mud used with respect to its ability to prevent loss of water to the formation, and to the fact that the average coring rate was in excess of 8 ft. per hour. Even if water from the drilling mud had migrated ahead of the core bit, the very nature of the occurrence of connate water is such that it is unlikely that a significant change in the relation of connate water to oil sand would have resulted.

Samples of formation oil sands from the core barrel contained relatively large quantities of water. An average of 29 per cent of the water was found to be from the drilling fluid; and, therefore, this quantity was foreign to the oil formation in place. The rest of the water, being connate, should be deducted from the total pore volume of the sand formation in order to obtain the net pore volume available to oil and gas. An arithmetical average of these deductions is approximately 38 per cent; i.e., that an average of 38 per cent of the total effective pores of the sands contained connate water. On an average, half of the remaining or net effective pore volume contained oil, and the other half gas.

These average values of formation contents are predicated on the assumption that expansion of the gas content of the sand on reduction of pressure, as the cores were taken from the well, did not cause loss of fluid, since an inspection of the cores showed no evidence of such action. No corrections were made for fluids lost by evaporation while the cores were exposed to the atmosphere at the well or in the laboratory, because the rapid handling of the samples precluded the possibility that such losses could be of sufficient magnitude to impair seriously the accuracy of the results.

In general, it is believed that the method used gives satisfactory results of such magnitude that they are of importance in estimating the fluid contents and the net effective pore volumes of oil-sand formations. It is not considered that data thus far accumulated are sufficiently complete for general application; and it is, therefore, intended to expand the work to include a variety of oil-formation conditions.

A Preliminary Investigation of Flowing Wells[1]

By EMORY KEMLER[2] and G. A. POOLE[3]

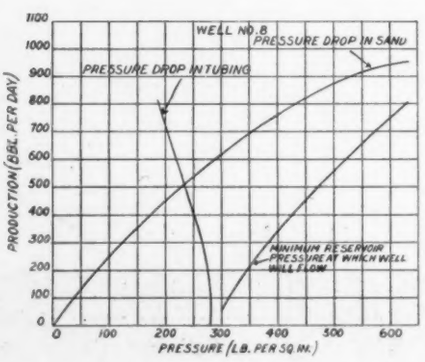
THE tests discussed in this paper were made to establish the characteristics of flowing wells, and to determine if the information that can be obtained from a detailed study would result in a longer flowing life and more efficient use of reservoir pressure and energy during the flowing period.

Among the problems having immediate application and of general interest, the following were chosen for study:

1. A study of formulas for calculating reservoir pressures, flowing rates, and well characteristics, with a view to determining their range and field of application.
2. The use of bottom-hole flowing pressure vs. production curves, for the determination of the well characteristic and the maximum production possible from a given well.
3. A method of determining the flowing life and future rate of production of flowing wells.
4. The collection of data on the pressure drop in flowing wells, to be used in:
   a. determining the proper size of tubing for any set of flow conditions;
   b. determining the proper flow rate for a given flow string and set of reservoir conditions.
5. The determination of flowing pressure vs. depth curves, to be used to study how a well flows.
6. To determine if it is possible to use the build-up curve as obtained from a recording pressure bomb, for the determination of the closed-in or maximum bottom-hole pressure.

[1]Abstract of paper presented at seventeenth annual meeting, American Petroleum Institute, Chicago, November 12, 1936.
[2]Gulf Oil Corp., Tulsa, Oklahoma.
[3]Gulf Oil Corp., Odessa, Texas.

Fig. 1. Well No. 8


WELL NO. 8
PRESSURE DROP IN SAND
PRESSURE DROP IN TUBING
MINIMUM RESERVOIR PRESSURE AT WHICH WELL WILL FLOW
PRODUCTION (BBL. PER DAY)
PRESSURE (LB. PER SQ. IN.)

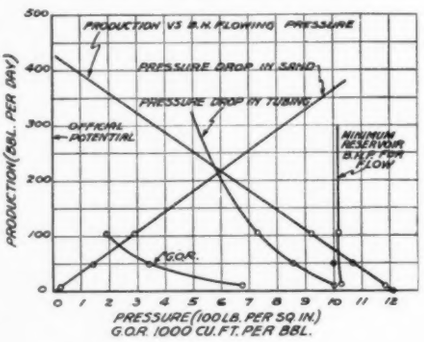

PRODUCTION VS B.H. FLOWING PRESSURE
PRESSURE DROP IN SAND
PRESSURE DROP IN TUBING
OFFICIAL POTENTIAL
MINIMUM RESERVOIR B.H.P. FOR FLOW
G.O.R.
PRODUCTION (BBL. PER DAY)
PRESSURE (100 LB. PER SQ. IN.)
G.O.R. 1000 CU. FT. PER BBL.

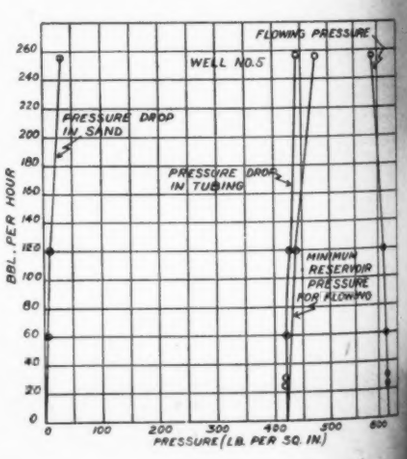
Fig. 2. Well No. 7

In this series of flow tests a newly-developed recording bottom-hole pressure gage was used for determining the flow pressures. The tubing pressures in some cases were taken with a recording-pressure gage. Where possible, these were checked by raising the recording-pressure gage to the top of the well and leaving it there for a time to get a recording of the tubing pressure. The results indicated that this method is desirable; because a recording-pressure gage, unless carefully checked each time, will not give pressure accurate enough for the purpose. The gas volumes were determined by the use of an orifice well tester placed on the gas outlet of the separator, and oil production was determined by measuring the level in the lease tanks. The velocities in the tubing strings were calculated by an empirical method which is not absolutely accurate, since it did not take into account the gas in solution.

The use of the well potential in the determining of the allowable production makes a knowledge of the behavior of a well assume an important rôle in the economic recovery of oil. There are two possible methods by which the potential of a flowing well might be increased. The first is to reduce resistance in the discharge line to a minimum and to select the proper tubing proportions to make the pressure drop in the tubing a minimum. This combination will then give the minimum pressure on the face of the sand when the well is flowing and, consequently, a greater production which will result from the greater pressure differential in the formation. In most cases not much increase can be brought about in this manner. In some cases such increases might be possible, but the resultant loss of reservoir energy to cause a higher gas-oil ratio will not be desirable.

The other possibility is to install a pump and put the well on the beam during the potential test. If the pump has sufficient capacity to handle the production, the pressure at the face of the sand can be reduced to a minimum, and the maximum production obtained.

Fig. 3. Well No. 5



Concerning the . . .

1938 INTERNATIONAL PETROLEUM EXPOSITION

Tulsa, May 14-21, 1938

The officers and management of the INTERNATIONAL PETROLEUM EXPOSITION take pleasure in announcing the Tenth exposition will be held as usual, in Tulsa, Oklahoma, May 14-21, 1938. This decision is in further co-operation with the oil industry and the exhibitors, who feel that there is justification for ONLY ONE OIL SHOW every other year.

Participation in a great petroleum exposition, whether by oil men, exhibitors or associations allied with the petroleum industry, represents an extraordinary expenditure of time, money and effort. Leaders in all branches feel that an annual oil show exacts too great a burden on the industry. It has therefore been the policy of the officers, directors and management of the International Petroleum Exposition to hold this greatest of all industrial expositions every two years.

W. G. SKELLY, President.

CELEBRATING FIFTEENTH ANNIVERSARY

The 1938 exposition will mark the Fifteenth Anniversary of the INTERNATIONAL PETROLEUM EXPOSITION. It will fittingly be celebrated. From a crude beginning in 1923, with what was not much more than a street carnival and home coming event, the big Tulsa oil show grew swiftly into the world's greatest exposition devoted to a single industry—and has held this unique position permanently. It is an exhibition of great educational value—an exposition of the latest methods and machinery devised by the ingenuity of man to solve the problems of the great petroleum industry—to increase efficiency, eliminate waste, bring safety to human life and protection to vast property investments. You'll want to have a part in this important anniversary event of a great world institution. Make your plans now.

Write for advance information on the 1938 Exposition.
Wm. B. Way, General Manager, Tulsa, Okla., U.S.A.

The World's Fair of the Oil Industry

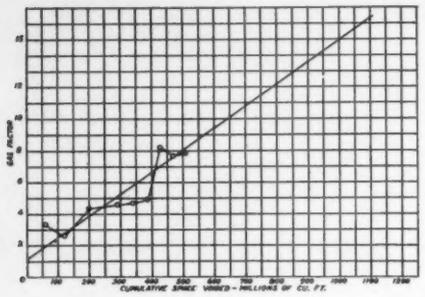


Fig. 4. Relation Between Gas Factor and Cumulative Production for Offsetting Edge Wells

The production rate that can be obtained from a well depends on both the history of the well immediately before the test is taken and on the length of time over which the test is made. If the well has been shut in and the bottom-hole pressure allowed to build up, the production rate will be quite high when the flow test is started, and will decrease with time until a steady state condition is reached. The reason for this apparent high production rate at the start of the test is that most of the oil is being produced from the well bore or the sand in the immediate vicinity of the well bore, and not from the reservoir proper as is the case when the pressures have reached a steady condition. The indications are that higher potentials can be obtained by closing wells in before the test and letting the pressure build up to the reservoir pressure.

This discussion is limited only to the problem of the determination of the minimum reservoir pressure at which the well will cease to flow a given production. The more general problem is the determination of the possible rates of production by flowing after a given amount of withdrawal. Any method of estimating the flowing life must necessarily be based on an assumed behavior of the reservoir. One method of getting an approximate value of the flowing life is shown in Figs. 1, 2, and 3. From data taken at various flowing rates the pressure drop in the tubing and sand can be obtained. By adding these two drops the total necessary for any given production can be determined. This, of course, is based on the assumption that the gas-oil ratio and other factors determining the pressure drop in the tubing remain the same; also that the pressure drop in the sand follows the same laws as when the test data were taken. Lack of any data on either of these items makes it impossible to predict what might be expected, but the method gives what would appear to be the minimum pressure at which the well would flow. The nearer the data are taken to the end of the flowing life, the more accurate the results should be.

Figs. 4, 5, and 6 show how the gas production varies with the production for the field. From such charts the future gas-oil ratio can be predicted, with only one qualification—this being that production methods continue on the same basis throughout the life of the reservoir. However, if any changes in operating conditions occur,

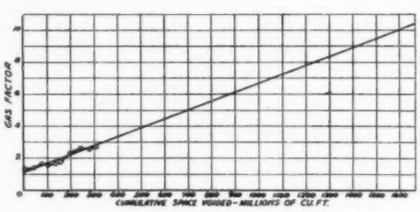


Fig. 5. Relation Between Gas Factor and Cumulative Production for Inside Wells

by re-calculating the gas-factor charts, future predictions may be made quite accurately.

Tests made indicate that there is a very definite increase of pressure drop per foot as the gas-oil ratio decreases.

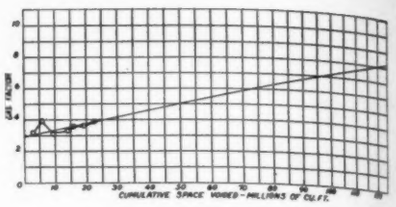


Fig. 6. Relation Between Gas Factor and Cumulative Production for Edge Wells

There is no consistent variation with tubing size. There is likewise no consistent variation with velocity. No information could be obtained on the amount of gas in solution in the different cases. While the data show very clearly that the gas-oil ratio is the most important factor in determining pressure drop in flow strings, they are not general enough to prove that it is the only item to be considered. These tests show that it will be necessary to obtain more accurate data on gas-oil ratios, as well as data on gas in solution, before any variation with tubing size can be found.

A direct method using well pressures is given for the determination of true closed-in bottom-hole pressures. A formula is presented and the results of the application of the formula to build-up curves on wells are given. The calculated values, using the initial values of bottom-hole pressure, may show calculated values considerably below the actual pressure. Calculated values obtained by using time intervals, starting 80 to 160 hours after the well was closed in, show a value that apparently is very little different from the actual final build-up pressure.

Formulas have been derived to give the amount of the available energy resulting from the expansion of gas that is in solution in the oil. These are also presented in the paper.

Drilling Important Test

United Foreign Oil Company, drilling Panorama No. 2 in the Panorama Hills oil field approximately 15 miles west of Taft, California, is now below 2200 ft. in a black sand. The company is preparing to install a lighting plant so that it may operate 24 hours a day. Testing operations, which will indicate the gravity of oil and the expected amount of production, are under way.

This well is of particular importance to a large number of residents of San Francisco and the Bay area inasmuch as the Panorama Oil Company pioneered the development of these famed hills a number of years ago and San Francisco capital is largely responsible for development work in the past.

Mixflo Pumps Described

A new, 8-page bulletin illustrating and describing the improved Mixflo centrifugal pump has been issued by the Worthington Pump and Machinery Corporation, Harrison, New Jersey.

The Mixflo, in sizes from 12 to 84 in., delivers from 1000 to 225,000 gal. per min. at heads from 5 to 50 feet.

Photographs, sectional drawings, and dimension tables are included in the bulletin. It contains a complete description of the parts of the pumps, together with technical information concerning modern trends in hydraulic design.

A copy of the bulletin, W-313-B1, may be obtained by request to the manufacturer.

Byers Announces Promotions

M. J. Czarniecki, vice-president in charge of sales, A. M. Byers Company, Pittsburgh, Pennsylvania, announces the following appointments that were made effective November 2, 1936:

George B. Cushing as manager of sales promotion. Cushing came with A. M. Byers Company in 1928 to organize and head the present advertising department and subsequently in 1931 organized a technical promotion group now known as the Engineering Service Department.

B. D. Landes, who has been in the technical group since its inception, has been appointed manager of the Engineering Service Department.

T. C. Winans, who has been in the advertising department since 1930, has been appointed advertising manager.

Both the manager of the engineering service department and the advertising manager become a part of the newly-formed sales promotion group headed by Cushing.

R. H. Gardner, formerly of the Washington office of A. M. Byers Company, has been appointed manager of pipe sales and will take over all sales management duties in connection with wrought iron and steel tubular products.

"Shock Lubrication"

"Shock Lubrication" is the latest term added to the vocabulary of automotive and lubricating engineers. Coined by a prominent engineer of one of the leading oil companies in connection with some experiments being conducted, the term encompasses those numerous conditions of operation when normal lubrication with oil is questionable.

In the automotive field for instance there is the condition of starting and warming up an engine. In the winter time it may take as long as five to 20 minutes, before the oil begins to circulate. In the meantime gasoline is not being completely vaporized and what oil remains on the cylinder walls is being washed off.

This explains why a noted oil company for instance advertises that "more wear occurs in starting an engine than in thousands of miles of normal driving."

Another place where effective lubrication with oil is questionable is at the top of the cylinder wall. Explosion temperatures run up to 3000 deg. fahrenheit. No oil can withstand that heat. Most oils burn at around 400 to 600 degrees. The result is that no oil exists on that part of the wall during the explosion stroke of the engine and the return stroke of the piston—resulting in piston ring and cylinder wall wear.

To find an answer to these vexing problems, tests have been conducted with colloidal graphite. The material it has been found has the faculty of becoming strongly affixed to the bearing surfaces and adhering there for hours of operation.

Even though the oil was not circulating properly, the colloidal graphite on the cylinder walls and bearings of the engine protects those parts in starting up and warming up. Being created in an electric furnace at 5000 deg. fahrenheit, the colloidal graphite was not touched by the high explosion temperatures.

While these factors have been recognized by many in the past, it has only been recently, with the increased speeds and horsepowers of engines that the matter of lubrication under "shock" conditions has been vital.

There are other "shock" conditions of lubrication in automobile engines. If engine oil gets hot under heavy running, the film strength of the oil decreases, until it is no longer strong enough to hold apart surfaces bearing against each other. Then rapid wear or seizure occurs, unless some more fixed lubricant which will not immediately run off or burn off is provided.

NEW when you get it . . . . as long as you use it . .

that's

PURCHASED ELECTRIC POWER!

You are not concerned with depreciation or maintenance on PURCHASED ELECTRIC POWER, because it's NEW when you get it and NEW as long as you use it. Its efficiency never declines; its dependability never falters. No insurance. No interest. No taxes. No incidental expense of any kind!

THE ONLY FORM OF POWER COVERED BY ONE BILL EACH MONTH

Your Power Company is ready with helpful facts, figures and precedents. Check your data with Power Company engineers before you install any prime mover for any oil country job.

PETROLEUM ELECTRIC POWER CLUB

DIVINING 18

DURING the nineteenth century the witch hazel divining rod reputedly possessed great ability to locate undiscovered ores, liquids, treasures, etc. Today's problems demand more accurate, certain methods.

Sure fire 20th Century formation testing does not rely upon myths nor superstitions. The Johnston Formation Tester is a highly successful and scientific instrument proved by the discovery of more than 15 important oil and gas fields.

SURE FIRE 20th CENTURY FORMATION TESTING

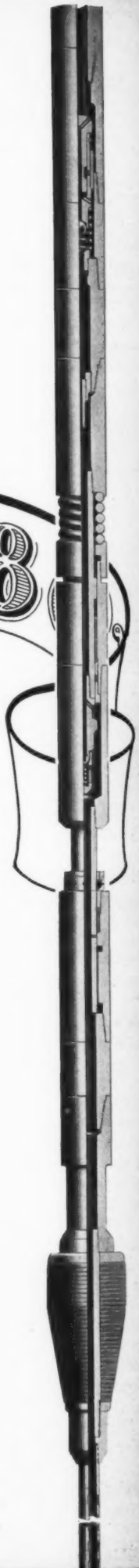
The Johnston Tester eliminates old-fashioned bailing methods for testing water shut-offs. It accurately measures rock formations and gas pressures — takes accurate samples of fluid from any desired formation in cased or uncased holes — differentiates between a test and a drill pipe leak — provides perfect safety to men and equipment in running each test.

Easy removal of the tester from the well is accomplished by means of the patented equalizing valve which relieves all excessive strain from the derrick when the string is lifted off bottom. Don't take a chance — use a Johnston Tester.

Operating a Johnston Formation Tester is as simple and safe as running a bit or core barrel. The valve mechanism is automatic. There is no turning or twisting the drill stem to open or close a Johnston Tester. Turning a long string of drill stem to open or close a valve at the bottom of a well is obviously uncertain and unreliable. The Johnston Tester opens by the weight of the drill stem and closes automatically the instant the weight of the drill stem is lifted. The trip valve on the Johnston Tester is further guarantee of a dry drill stem until the operator is ready to test the formation.

M. O. JOHNSTON
OIL FIELD
SERVICE CORP.

3117 San Fernando Road
Los Angeles, Calif.

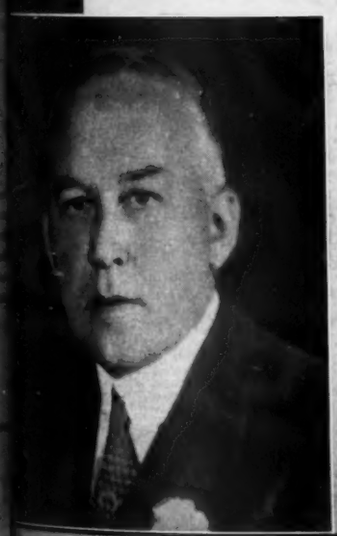


Pictorial Petroleum

November, 1936

1936 NATIONAL OFFICERS AMERICAN PETROLEUM INSTITUTE WHICH HELD SEVENTEENTH ANNUAL MEETING, CHICAGO NOV. 9-12

Left—Axtell J. Byles, Pres.; Right—W. R. Boyd, Jr., Executive V.-Pres.; Below (left to r.)—C. E. Arnott, Chairman, Marketing Div.; Lacey Walker, Secretary and Asst. Treas.; Geo. A. Hill, Jr., Chairman, Production Div.; Bottom (l. to r.)—K. R. Kingsbury, V. P.; Jacob France, Chairman, Refining Div.; Bair H. Markham, Director of Petroleum Industries Committee.



A REGULAR FEATURE OF THE PETROLEUM ENGINEER

Some of the Presiding Officers and Committeemen A.P.I. Annual Meeting Held Chicago, Nov. 9-12

Top Left—Blaine B. Wescott, chairman Div. of Production Program Committee; Top Right—Marion E. Brocke, chairman of Div. of Production Nominating Committee; Left—Arthur E. Pew, Jr., chairman Div. of Refining Nominating Committee; Above—J. B. Rather, presiding officer, Div. of Refining, morning session, November 12; Right—Hugh Scott Taylor, speaker at general afternoon session, November 11; Below, Left—T. V. Moore, presiding officer, Div. of Production, afternoon session, November 12. Below, Right—C. W. Froome, presiding officer, Div. of Production, evening session, November 10; Below—J. T. Hayward, presiding officer, Div. of Production, morning session, November 12.

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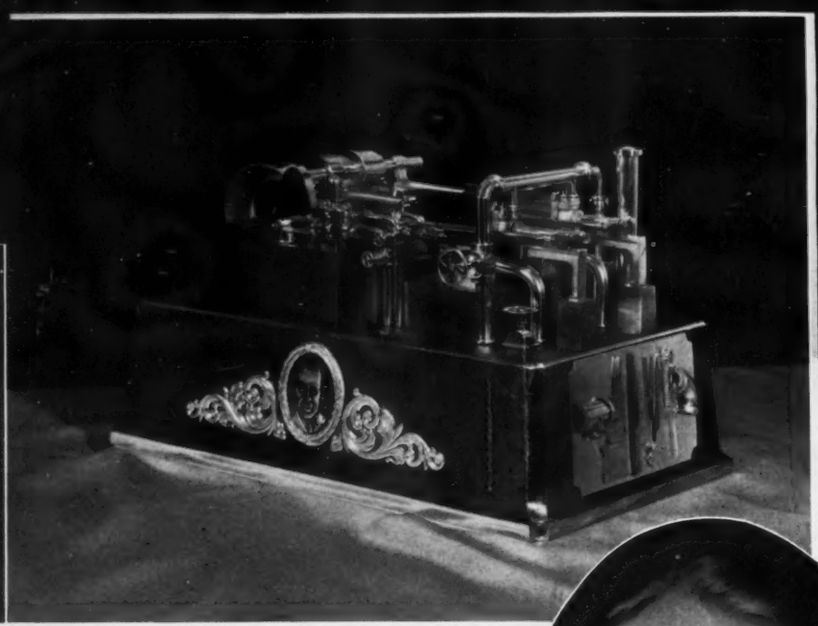
Presented to E. H. Leroux



E. H. LEROUX
Retired October 23, 1936

In appreciation of our honored and respected President for the gracious consideration bestowed upon the personnel of the entire company and with best wishes for a long and happy future, from employees of the Oklahoma Pipe Line Company.

Upon the recent retirement of E. H. Leroux as president of the Oklahoma Pipe Line Company, employees of the organization presented him with a sterling silver model of a pipe line pump, two photographs of which are reproduced here. The model is an exact replica of a National Transit pump installed by Mr. Leroux himself when he first became a member of the company.

Mr. Leroux's retirement came after 31 years of continuous service for the Standard Oil Company of New Jersey. During his long association with the pipe line business he made a huge number of friends, among the most faithful of whom were the men closest to him, the 500 employees of the Oklahoma Pipe Line Company. Each of the latter was proud to participate in the cost of the trophy, which is one of the most unique ever designed. The trophy is the work of F. C. Ziegler, jeweler and silversmith, who was instructed to reproduce exactly the National Transit ranger type pump still in daily operation at the Glenpool, Okla., station of the Oklahoma Pipe Line Company.

At one end of the base is reproduced some of the tools in use 30 years ago, including two wooden pipe jacks, a Klein tong, also manufactured by the National Transit Pump & Machine Company, a Vulcan chain tong manufactured by J. H. Williams & Co., and some old-time flanged fittings. All are true to scale. At the other end of the base modern equipment is faithfully reproduced. This includes an Oxweld acetylene welding torch and tank manufactured by The Linde Air Products Company, and Tube-Turns fittings manufactured by Tube-Turns, Inc.

On one side of the base is a silver carving of Mr. Leroux. On the other is the inscription reproduced above.

In all 539 individual pieces, representing eight pounds of sterling silver, were required to build the pump which, in its entirety, weighs 39 pounds. Its modeling required 600 hours.

IN *Any* LANGUAGE

Like the common safety pin, which because of its positive action and protection against "accidents", has become recognized as an international symbol of safety, so have BJ Production Tools, because of the absolute protection they afford, become recognized as a symbol of highest safety wherever oil field equipment is used.

BJ PRODUCTION TOOLS

And Features that Make Them REALLY 100% SAFE IN SERVICE

BJ ROD AND TUBING HOOKS

BJ "Locking Arm", which locks automatically and positively cannot open while hook is in use. No danger of bail jumping out, and its construction and locking mechanism eliminate hazard of metal fatigue and crystalization • Positive and easy method of lubrication assures proper operation of spring, and ease in swiveling • Hand guards for additional protection to operator; an optional feature • Entire hook assembly is streamlined, eliminating any possibility of catching hands or clothing on protruding nuts or sharp corners.

BJ SURESTOP TUBING CATCHER

Its positive operation eliminates danger of dropping a string either after tubing has been run in, or while running in or out • The anchoring method prevents "breathing" of tubing and removes the hazard and expense of excessive wear on couplings or casing • Large slips grip firmly when they set, but due to their large contacting area, will not bulge or damage casing • When an accident causes BJ Tubing Catcher to set, the large area slips, with diagonal-cut teeth, are released easily without damaging casing or tubing.

Experienced operators do not gamble with the safety of their well or equipment, but specify BJ Production Tools PROVED BY PERFORMANCE to afford absolute safety under all operating conditions.

Look for **BJ** in the COMPOSITE CATALOG

BYRON JACKSON CO.
PORT WORTH • LOS ANGELES • NEW YORK

THE AMERICAN PETROLEUM EQUIPMENT SUPPLIERS' ASSOCIATION
MEMBER

Operating Men in Wyoming and Montana Fields

1

2

3

4

5

1. Left to Right—W. A. Peterson, V. L. Taylor, and J. A. Heeren, all petroleum engineers with Stanolind Oil & Gas Co., Midwest, Wyoming.
2. Left to Right—B. R. Walker, Supt., Stock Oil Company; F. R. Nelson, Supt., Orchard Oil Co.; H. B. Gernert, field foreman, The Texas Company, all of Cody, Wyoming.
3. D. E. Straitiff, Pres., Rocky Mountain Drilling Co., Casper, Wyoming.
4. Left to Right—C. E. Johnson, Asst. to Dist. Supt.; J. B. Shanks, pipe line foreman; W. E. Ulery, Asst. Supt., gasoline plant; Max Hill, pipe line foreman and Walter De Groat, pipe line Supt., all with Stanolind Oil & Gas Co., Midwest, Wyoming.
5. Left to Right—Chas. M. Laudermilk, Hinderliter Tool Co., Shreveport, La.; R. L. Maxwell, tool pusher, Bridger, Montana; Ralph Will, drilling Supt., Casper, Wyoming, and P. L. Frederick, driller, Lovell, Wyoming, the latter three with R. M. Drilling Company.
6. Left—R. R. Ullstrom, Dist. petroleum engineer, and C. J. Christensen, petroleum engineer, Stanolind Oil & Gas Co., Midwest, Wyoming.
7. E. L. Decker of Martin-Decker Corporation, who, when the photograph was taken, was visiting W. H. Smith (right), store manager for Reed Roller Bit Company, at Casper, Wyoming.
8. R. G. Kennelly (left), foreman, gasoline plant, Continental Oil Company, Salt Creek, Wyoming, and F. A. Gorman, pipe line contractor, Casper, Wyoming.
9. E. B. ("Hardrock") Coolidge, independent operator, Great Falls, Montana.

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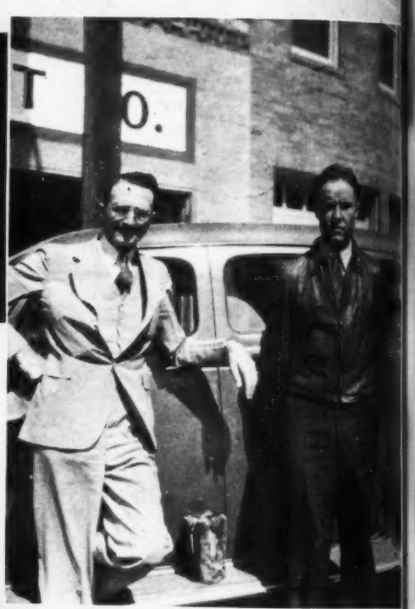

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9

SAFETY FROM TOP TO BOTTOM with B.S.&B. High Duty Oil & Gas SEPARATORS

OUR GUARANTEE

We guarantee that each B. S. & B. High Duty Oil and Gas Separator and/or Gas Scrubber will separate oil from gas so completely that less than one one-thousandth (.001) of a gallon of liquid oil spray will be lost with each 1000 cu. ft. of gas discharged, provided it is operated within our capacity rating for its working pressure, and provided it is kept properly clean of sand and b. s. deposits.

Signed. . .

BLACK, SIVALLS & BRYSON, INC.

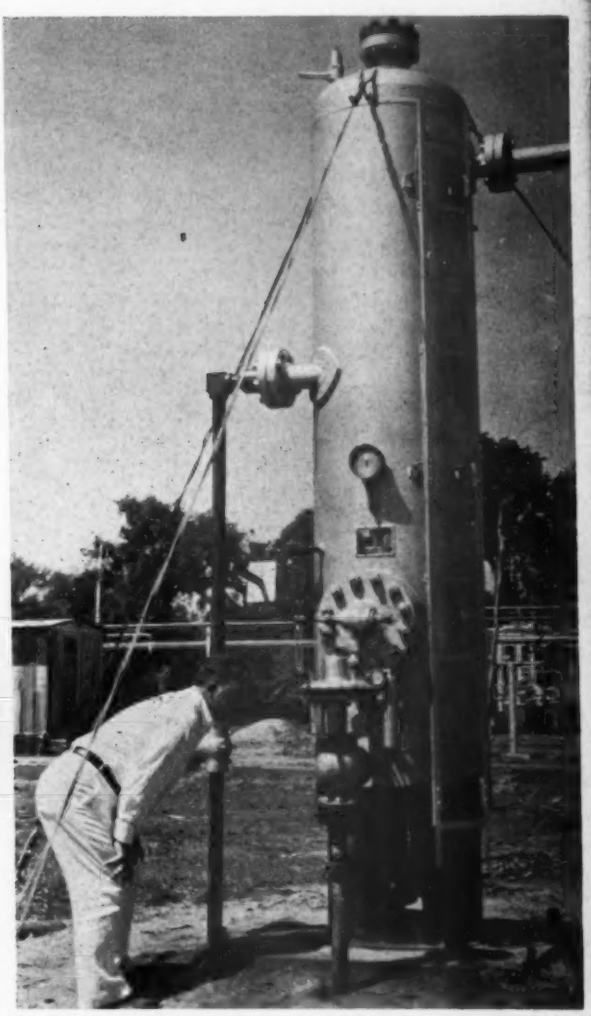
B. S. & B. SEPARATOR DRYNESS TESTER PROVES OUR GUARANTEE

With the B. S. & B. Separator Dryness Tester, our engineers are accurately measuring any least amount of oil spray left entrained in the gas. (Patent Pending.)

From the ground up, BS&B High Pressure Oil and Gas Separators are *safe, rugged, efficient.*

Made of boiler code flange steel, their flex-welded seams are X-ray tested. They are stress-relief annealed.

All high pressure (500 lb.) and extra high pressure (1000 lb.) BS&B Oil and Gas Separators are equipped with BS&B Bottle Tight Pilot Oil Valves and BS&B Safety Heads. *They comply strictly with the A.P.I.-A.S.M.E. Code.*



B. S. & B. BOTTLE TIGHT PILOT OIL VALVES

Manufactured in our own shop, these valves, both High Pressure and Low Pressure, are guaranteed to be strictly tight when installed and to remain strictly tight for a period of one year unless subjected to abnormal and excessive abrasion.

B. S. & B. SAFETY HEADS

To "top off" and insure against all unexpected field hazards growing out of excessive pressures, all B. S. & B. Separators are equipped with the famous B. S. & B. Safety Heads.

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Black, Sivalls & Bryson (INC.)

OKLAHOMA CITY

The Grasshopper and The Hare

They grow 'em big in the Mid-Continent

A West Texas Jackrabbit

On the Way to the Kansas Oil Fields

RIGHT—A group of employees of The Chemical Process Co., Inc., taken at their Seminole branch. (Left to right): E. Taylor, E. Fitswilliams, H. E. Dysert, Bob Caffey, J. B. Russell (field man for Hinderliter Tool Company), T. S. Lancaster, A. W. Stone, W. S. Pate, O. H. Thompson, Walter Blanks, J. B. D. Woodburn, and C. H. Hogan from the main office at Breckenridge, Texas. BELOW—Construction work on The Texas Company's new gasoline plant No. 14 at Montebello, California.

ACID TREATING

- is a business for specialists—a business for practical oil men who know what is going on under the ground—from the grass roots down to the bottom of the hole.
- They must not only know formations and pressures, but must have had that practical experience in the oil business and the acid business which will enable them to give the particular formation to be treated the proper tratment for best results.
- It is men like this who operate the units of the CHEMICAL PROCESS COMPANY; men who KNOW, not only from theory, but from years of practical experience—men who are SAFE to entrust with the delicate job of salvaging your old well or bringing in your new one.
- The fact that the CHEMICAL PROCESS COMPANY has treated more wells in the Mid-Continent area than has any other company is, in itself, sufficient evidence of the skill and efficiency of its organization; an organization that is ready for immediate service throughout the States of Texas, Oklahoma, Kansas, New Mexico and Louisiana.
- Our acid treating experts will be glad to analyze your special problem and give you the benefit of their experience gained in successfully treating thousands of wells. Our laboratory is at your service for free tests of samples.

Phone, wire or write your nearest Chemical Process Company service station (listed below)

CHEMICAL TREATMENT OF OIL AND GAS WELLS

THE CHEMICAL PROCESS CO., Inc.

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TEXAS
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206

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Tel. 2-2478—RUFUS CLAY.
RUSSELL, KANSAS—
Tel. 493—C. R. VINCENT.
WICHITA FALLS, TEXAS—
Tel. 2-4307—W. E. (Bill) NORTON
BRECKENRIDGE, TEXAS—
Tel. 206—P. W. PITZER, C. K. WEST, G. R. WHITNEY.

LULING, TEXAS—
Tel. 365—O. R. WELLS
HOBBS, NEW MEXICO—
Tel. 444—P. W. MORRISON
ODESSA, TEXAS—
Tel. 21—C. F. HOGAN
SEMINOLE, OKLAHOMA—
Tel. 844—J. B. D. WOODBURN.

S. W. DARLING, who has been superintendent of The Texas Company's refinery at Amarillo, Texas, has been transferred to Houston and made superintendent of the refinery there. **G. C. McSWAIN** is the new superintendent of the Amarillo refinery.

R. D. MORIARTY, superintendent of purchasing for the Standard Oil Company of Venezuela, at Caripito, is in the United States on his vacation.

E. F. STEIGELMAN has been promoted by the Standard Oil Company of California from assistant district purchasing agent, San Francisco, to the post of district purchasing agent, Los Angeles. **C. V. LANE,** who has been head buyer, Los Angeles, has taken over Steigelman's vacated position.

J. C. RECTOR, formerly superintendent of gas operations, southern division, for the Union Oil Company of California, has been made superintendent of gas operations with jurisdiction over the Valley, Coast, and Southern divisions.

THOMAS D. FOSTER, Punjab, India, assistant drilling superintendent for the Attock Oil Company, Ltd., and Mrs. Foster, are in the United States on their vacation. Foster will visit a number of the leading fields of this country before returning home.

P. C. BLACKMAN is a new member of the chemical staff of the Mid-Continent Petroleum Corporation at Tulsa, Oklahoma. He formerly was with the Empire Oil and Refining Company at its Tallant, Oklahoma, gasoline plant.

RUSH GREENSLADE, Tulsa, Oklahoma, vice-president of the Gulf Oil Corporation, at present is making a tour of South America.

W. A. MAY has been made district superintendent for the Texas Pipe Line Company, having his headquarters at Corpus Christi, Texas. He was transferred from Tyler, Texas.

HENRI DETERDING, general manager of the Royal Dutch Petroleum Company, The Hague, will retire January 1st, it is announced. His successor will be **J. E. F. DeKOK,** manager of the Royal Dutch Shell.

J. T. RUSSELL, chemist for the Panhandle Eastern Pipe Line Company, now has his headquarters at Liberal, Kansas, having been transferred from Louisburg.

GUY McGOWAN has been made superintendent for the Russ Petroleum Company, W. P. Luse and D. S. Hager, who are partners, and will have charge of their drilling operations in the Sulphur Bluff, Texas, field.

A. G. LEVY, who has been in the Houston, Texas, office of The Texas Company, has been transferred to Shreveport, Louisiana, and made senior petroleum engineer in that district.

RICHARD D. ROBEY, JR., has severed his connection with the Olson Drilling Company and the Olson Oil Company, of which he was vice-president, to become an independent operator. His initial activities will be in Southern Kansas.

JOSEPH B. UMPLEBY, engineer and geologist, has moved from Norman, Oklahoma, to Seattle, Washington.

CECIL BURTON, vice-president of the Burton Drilling Company, now has his office in Houston, Texas. Formerly he was at Tyler.

C. B. MILLER, purchasing agent of the Gulf Oil Corporation at Maracaibo, Venezuela, has been spending his annual vacation in the United States. He was a recent visitor in Shreveport, Louisiana.

E. E. BOYLAN, manager of the Caracas Petroleum Corporation, has returned to his headquarters in Venezuela following a vacation in Europe and the United States.

CARL NEWCOMB of the Standard Oil Company of California has sailed for Sumatra, where he will be in charge of contemplated operations.

D. R. N. PICKARD, of the drilling department, and **H. R. SAYERS,** of the production department, of the Anglo-Iranian Oil Company, Ltd., are in the United States to study field problems.

W. ALTON JONES, executive vice-president of the Cities Service organization; **TEMPLE W. TUTWEILER,** member of the executive committee; **GEORGE SHAW,** special counsel; **H. R. STRAIGHT,** vice-president and general manager of the Empire Companies; **A. W. AMBROSE,** assistant general manager of Empire; and **M. R. SHAFFER,** manager of oil production for the Empire, recently made an inspection tour by plane of the company's properties in the Mid-Continent.

C. A. P. SOUTHWELL, manager of fields, Anglo-Iranian Oil Company, London, England, arrived in the United States for a visit of several weeks. He is accompanied by **H. W. LANE** of the Iranian (Persian) fields.

G. A. WOODS, for nine years superintendent of the Canadian River Gas Company at Amarillo, Texas, has been made manager of the Southwestern Division of Ford, Bacon and Davis, Inc. His headquarters are at Dallas, Texas.

H. E. GROSS, petroleum engineer in the exploration department of the Shell Petroleum Corporation at Tulsa, Oklahoma, has resigned to accept a professorship in the School of Petroleum Engineering, University of Oklahoma, Norman.

E. V. HANZAN, division engineer, and **W. S. CRAKE,** mechanical engineer, with the Shell Petroleum Corporation, have been transferred from Corpus Christi, Texas, to Houston as a result of the closing of the company's production office at Corpus.

LAUGH WITH BARNEY

Edited by BARNEY HORRIGAN

"That bruiser of a subway guard isn't so awfully tough as he's supposed to be."

"No? How's that?"

"When I fell down, he wiped his feet before he stepped on my face."

* * *

"Three hair nets, please."

"What strength?"

"Two dances and a car ride."

—*Punch Bowl.*

* * *

Collegiate Courtesy

Freshman: Say, what's the idea of your wearing my raincoat?

Roommate: Well, you wouldn't want your new suit to get wet, would you?

* * *

"Your dress is too short."

"I don't think so."

"Then you must be in it too far."

—*Jester.*

* * *

There had been a big family row; the police had been called; Mr. Blank was hauled into police court for beating his wife. The magistrate rebuked him severely.

"You ought to be ashamed of yourself," His Honor began, "assaulting your wife like that. I never saw a nastier black eye. Do you know of any reason why I should not send you to prison?"

"If you do," answered the defendant, "it will break up our honeymoon."

* * *

The teacher had forbidden the eating of candy and chewing of gum during school time. One day she became suspicious of a lump in Jimmie's cheek. "Jimmie, are you eating candy or chewing gum?" she asked.

"No," replied Jimmie. "I'm just soaking a prune to eat at recess."

* * *

The car was moving along a lonely road. Suddenly from under the hood came a terrific knocking. The car came to a stop.

He: Heck, I wonder what that knock is?

She: I think it's opportunity, baby.

* * *

She was just a quarryman's daughter — you could take everything for granite.

A customer sent this note to his grocer:

"Please send six dozen eggs; if good, I will send check."

The grocer, however, was not doing any business on such risky terms, so he replied:

"Send check; if good, I will send six dozen eggs."

* * *

Uncle Joe has been having such interesting dreams lately that he's taken to wearing his spectacles to bed.

* * *

Mother (to small child of eight years): Hush, dear, the sandman will be here soon.

Child: O.K., Mom. Gimmie two lollypops and I won't tell daddy.

* * *

Teacher: George, I'm surprised! Do you know any more jokes like that?

George: Yes, teacher.

Teacher: Well, stay after school.

* * *

Doting Mother: You must grow up to be good. Don't you want to be looked up to?

Doted Daughter: No, I'd rather be looked around at.

* * *

It is reported on unimpeachable testimony that out in West Texas during the recent drouth the trees were actually following the dogs around.

* * *

The absent-minded professor who sent his wife to the bank and kissed his money good-bye wasn't so blamed absent-minded at that.

* * *

"If he asks me I'll say 'Yes.' It doesn't make much difference. He's clever and good-looking. His hands are gentle. I like to feel them in my hair. I think he would treat me all right. If he doesn't ask me, all right — but if he does, I'll say 'Yes'."

"Shampoo, Madam?"

"Yes."

* * *

Officer: You've been doing sixty miles an hour. Don't you care anything about the law?

Lady: Why, officer, how can I tell? I've only just met you.

—*Bridgeport Bulletin.*

* * *

Before marriage a man yearns for a woman. After marriage the "y" is silent.

The only time a horse gets scared these days is when he meets another horse.

* * *

Have you heard of the girl whose boy-friend gave her a kiss so hot that it burned her husband up?

* * *

Dean: So, you're back in school. I thought that I expelled you last week.

Upstart: You did, but don't do it again because my dad was plenty sore.

—*S. California Wampus.*

* * *

A small boy was about to purchase a ticket for a movie in the afternoon. The box-office girl asked:

"Why aren't you in school?"

"Oh, it's all right, ma'm," said the youngster, "I've got the measles."

* * *

"Why didn't you shave this morning?"

"I thought I did but there were twelve of us using the same mirror this morning and I must have shaved some other guy."

* * *

"Is your wife economical?"

"Sometimes. She used only thirty candles on her fortieth birthday."

* * *

"I just brought home a skunk."

"Where ya gonna keep him?"

"I'm gonna tie him under the bed."

"What about the smell?"

"He'll have to get used to it like I did."

* * *

First: Someone has to teach the freshman co-eds wrong from right.

Second: Okay, pal, you teach them what's right.

—*Penn State Froth.*

* * *

Of all the "Give-me-a-sentence-with-the-word" jokes we've heard, we give the prize to the lad who put effervescent and fiddlestick in one sentence. He said, "Effervescent enough covers on the bed your fiddlestick out."

* * *

"There's a boy called John Simpson working here. May I see him? I'm his grandfather."

"You've just missed him. He's gone to your funeral."

* * *

The slogan for a nice night's entertainment: So-fa and no-father.

FUN-*da-mentals*

EDITOR'S NOTE **If yours appears in this space, we will send you the original artist's drawing (done in full colors).**

WE WANT YOU ON OUR EDITORIAL STAFF... HERE'S HOW!

Now is your chance to exercise a spare brain cell. Write a FUN-*da-mental* for us. FUN-*da-mentals* are mental gymnastics full of fun and facts—truths in the guise of the vernacular. Here's the way you proceed:

First: You must be a subscriber to THE PETROLEUM ENGINEER; that is, the signature appearing on your contribution must correspond with that on our subscription list.

Second: Just turn yourself loose and write a verse—we will furnish the cartoon interpretation each month of the one we consider to be the best.

Third: For the FUN-*da-mental* we select as suitable for first prize we will mail to the author the beautiful water color original drawing from which the engraving is made.

Fourth: For each FUN-*da-mental* that is selected to appear in this column, other than that winning first prize, we will mail to the author a check for $1.00.

All FUN-*da-mentals* must be signed by the originator or author.

All FUN-*da-mentals* sent to us shall remain the property of THE PETROLEUM ENGINEER.

We reserve the right to accept or reject any or all FUN-*da-mentals* and our judgment shall be final.

NOW . . try your hand at this contest—who knows but that you will be the lucky author and receive a beautiful water color cartoon interpretation of it framed and ready to hang on your wall.

There was a gent named Titus
With a case of "second-hand-itus."
He kept junk together
With wire and leather,
And they named the creation St. Vitus.

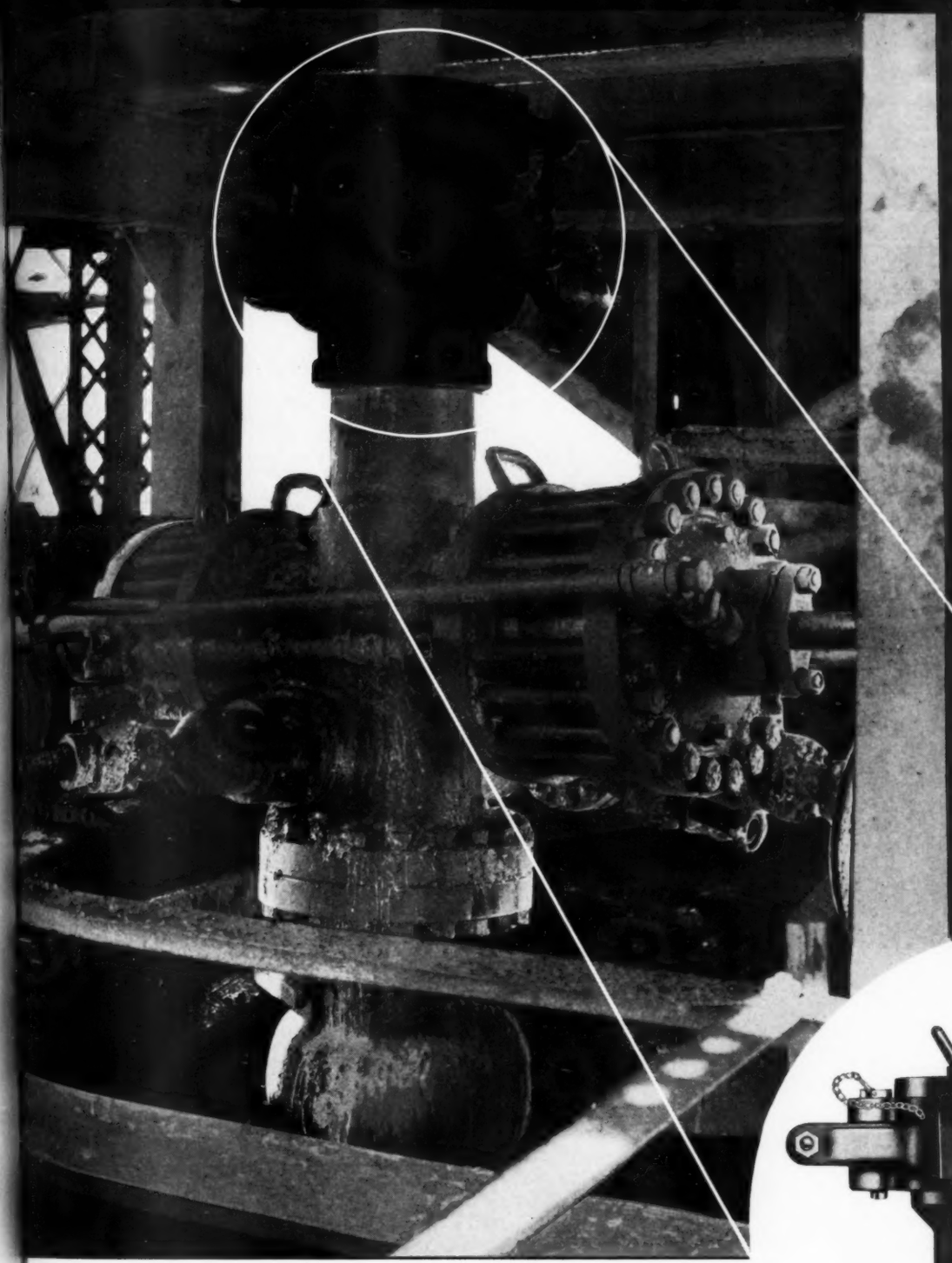
By JOHN H. DOE, Superintendent,
Maximum Oil Company.

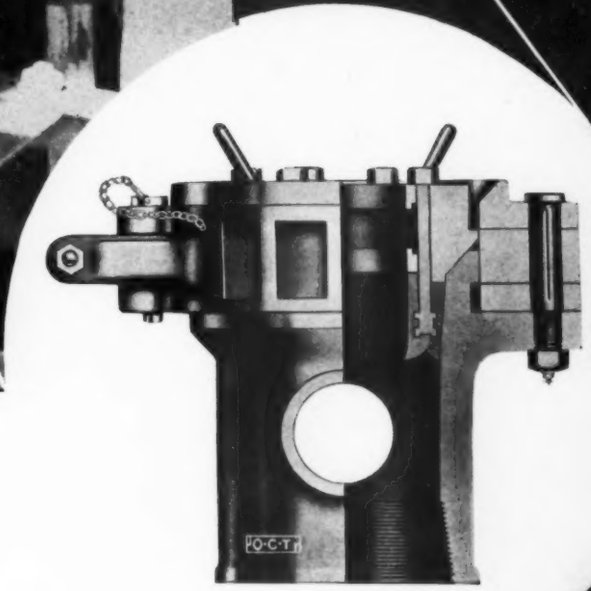
There was a man named McHinery
Who was handy with makeshift machinery,
Though his boss liked the cost
In the end all was lost,
And now he is clerk in a beanery.

By HERBERT M. SMITH, Engineer,
So and So Oil Company

. . . and, if it appears in this column we will send you a check for $1.00.

WRITE A FUN-*da-mental* AND SEND IT IN TODAY!





There's DOUBLE-SAFETY under THIS DERRICK FLOOR

The O-C-T Type "D" Above This Ram Type Makes An Unbeatable Blowout Preventer Combination

is combination blowout preventer hook-up is rapidly be-ing familiar throughout high-pressure areas of the oil stry.

ith complete safety, while circulating through the closed -T Type "D" Preventer to kill kicking well pressure, drill may be rotated continuously, and raised and lowered inuously to prevent sticking. If desired or necessary, drill may be lowered back to bottom to "heavy-up" the full m of drilling fluid.

event of a blowout, rams of the pressure operated ram-preventer are closed. Pack-off of the O-C-T Type "D" nter is then inserted in the preventer body, and rams of ram-type preventer opened. All wear is concentrated on the pack-off of the O-C-T Type "D" Preventer. In event of necessity to change this pack-off, which can be done in very few minutes, rams of the ram-type preventer are closed to hold well pressure while the change-over is made.

O-C-T Pack-offs are made for drill pipe, tubing or casing, either standard or flush joint. Collars or tool joints pass through the O-C-T Pack-offs without loss of pressure.

Four types of O-C-T Blowout Preventers enable you to meet every condition encountered in today's drilling. Parts for all four types are interchangeable, eliminating the necessity of a separate supply of parts for each type.

Full details covering the O-C-T Preventer Line will be mailed to you on request.

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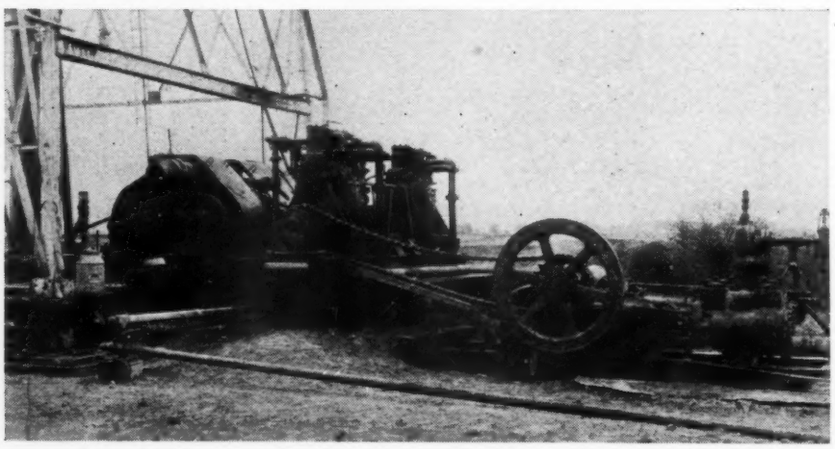
CABLE ADDRESS "OCENTOL"

MACHINERY and EQUIPMENT

"Oilwell" Portable No. 7 Double Engine Drive

THE Oilwell Supply Company has announced the "Oilwell" Portable No. 7 Double Engine Drive, consisting primarily of two 7¾-in. by 7-in. vertical twin-cylinder double-acting steam engines with power-takeoffs mounted in line on a structural-steel base to form a self-contained prime mover plant for a rotary drilling rig. Portability, flexibility, and economy of first cost, maintenance, and operation are the advantages claimed for the drive by the manufacturers.



Installation in the Lyons Field, Kansas

Manifold, control equipment, and clutches are arranged so that in regular drilling service the engines operate independently, one driving a power slush pump, the other a rotary. For hoisting, however, they are connected and operate as a single prime mover.

The power take-off to hoist and rotary consists of an intermediate shaft with a 15-18 tooth double-drive sprocket for No. 4 A.P.I. chain placed between two dust-proof grease-packed self-aligning roller bearing pillow blocks. The shaft is coupled to the drilling engine by a chain-type flexible coupling and to the pump-drive engine by a hand-lever-operated close-clearance jaw clutch that is engaged only when the two engines are operated in tandem for hoisting.

A double-roller chain drive from a clutch sprocket mounted on an extension fitted to the pump-drive engine crankshaft comprises the power take-off to the pump. The clutch is manually operated.

The frame upon which the engines, power take-offs, and clutch controls are mounted is of all-welded construction.

A remote variable cut-off, reverse and throttle control for mounting on the hoist post at the driller's position is supplied as standard equipment with the No. 7 Double Engine Drive. When operating in tandem for hoisting, the reverse lever shafts are interconnected and one throttle valve is used for both engines, which are controlled as a unit by the remote control device. During normal drilling operation (rotating), only the drilling engine is remotely controlled from the derrick floor, and the pump drive engine is regulated separately.

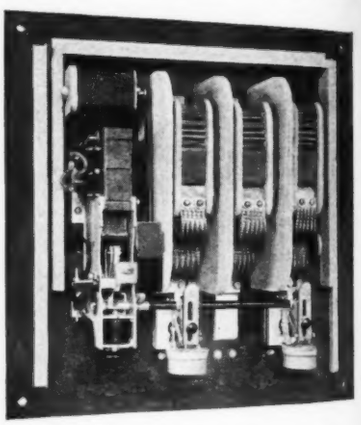
A specially-designed steam intake manifold consists of a 4-in. header or common supply pipe, a 3-in. steam line with throttle valve for header to drilling engine, a 3-in. steam line with globe valve for header to pump-drive engine, a 3-in. bypass steam line with globe valve interconnecting the steam lines to both engines beyond the respective control valves, and a 3-in. universal pipe joint adjacent to each engine to allow for expansion and slight misalignment in assembly.

Type AE-1 Air Circuit Breaker

A NEW air circuit breaker, Type AE-1, adapted to industrial and station auxiliary service, or for any heavy duty where many opening and closing operations are required, has been announced by the General Electric Company, Schenectady, New York. The breakers have a 20,000-amp. interrupting rating and are for operation on circuits of 250 volts d-c. and 600 volts a-c. at 15 to 600 amperes.

The standard arrangement is an enclosed breaker with pull box for mounting on a wall or behind a switchboard panel; without pull box, for mounting on the front of the switchboard. Main contacts are silver-to-silver; arcing contacts are of special alloy. Double-and-triple-pole units are available.

A selective overload feature differentiates between overload and short



circuits, time delay being provided up to six to ten times calibration setting and instantaneous above that. The mechanism is electrically operated, trip-free, and latched-in with a solenoid suitable for either a-c. or d-c., depending upon rating.

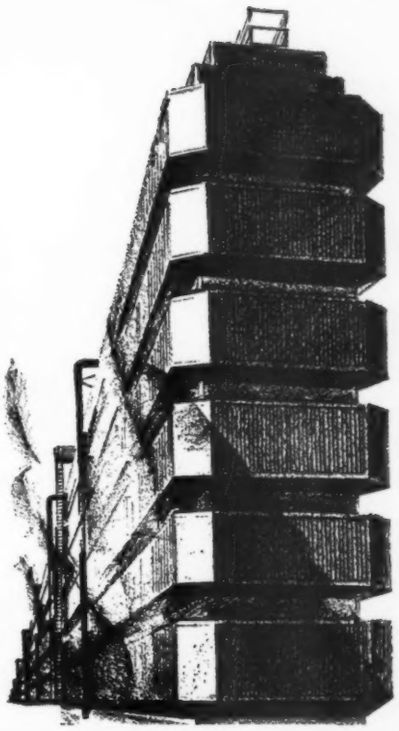
The unit is completely enclosed with the base included within the case. The approximate dimensions with pull box are 19 in. wide, 21 in. high, and 21 in. deep; without pull box, the depth is nine inches.

.... IMAGINE A COOLING TOWER 2 MILES LONG

During the first eight months of 1936 over two miles of cooling tower has been constructed by the Fluor organization for the oil and gas industry. Installed in sectional units of varying lengths, Fluor Aerator Type Cooling Towers are rendering efficient service in nearly every section of the nation.

The noteworthy fabrication of two miles of cooling tower in eight months was not accomplished either through super-selling or unprecedented demand — it has been the direct result of an established preference for Fluor design, engineering, workmanship and proven operating principles.

Write today for your copy of Bulletin T-236, giving full details on Fluor Aerator Type Cooling Towers.



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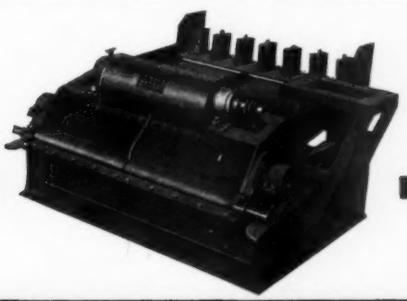
909 McCormick Bldg., Chicago, Ill. : 30 Church St., New York City, N. Y.
1402 Esperson Bldg., Houston, Texas

BE SURE WITH FLUOR

FLUOR AERATOR TYPE COOLING TOWERS

KEEPS MUD CLEAN AT *LOWEST* COST



ADVANTAGES engineered into the McNEELY Vibrating Mud Screen assure a uniform, clean drilling fluid at *lowest* cost.

Long screen life (often 10 to 12 weeks of continuous service) saves money. A curved screen surface (an exclusive feature) assures rapid removal of waste cuttings and provides greatest operating efficiency. The all-steel construction, and use of quality materials throughout, provides a ruggedness that keeps the McNEELY Vibrating Mud Screen on the job *longer!*

Ask your Supply House, see Page 1279 Composite Catalog or write for details.

The **McNEELY** *Vibrating* **MUD SCREEN**

VERNON TOOL CO., LTD.
2740 East 37th St., Los Angeles, Calif., U.S.A.
Gulf Coast and Mid-Continent Representative
BAROID SALES CO., HOUSTON, TULSA
EXPORT
The National Supply Corp. Oil Well Supply Co.

This Picture shows you
WHY MacCLATCHIE STREAMLINED PUMP VALVES ARE BETTER

MacClatchie's are pleased to announce that they have greatly improved the steel in MacClatchie Pump Valve Seats. Users can expect 25% to 40% better service from all MacClatchie Valve Seats manufactured since October 15, 1936.

40% MORE STRIKING SURFACE

Pump Valves in operation, especially under high pressure, are subjected to constant pounding and terrific impact. This impact must be absorbed by as large an area as possible. Realizing this fact, MacClatchie engineers years ago developed the patented MacClatchie Streamlined Valve, utilizing all of the cross bar and part of the large area of the seat for striking surface. This large striking surface, plus the Streamline design, accounts for the world-wide popularity of MacClatchie Valves and their choice by those operators who keep records of pump valve costs in every kind of digging and under all pressures.

For years MacClatchie engineers have constantly tested and tried practically every conceivable design of valve, but have found nothing that, under every condition, gives the uniform long life of the present design. They are constantly experimenting to improve the material and method of manufacturing. MacClatchie was the first to offer the trade hardened and ground seats, individually wrapped, oiled and in heavy cardboard containers. MacClatchie seats are so machined, designed and packed that they come to you as nearly perfect as humanly possible. Therefore, cut-out mud ends are unknown to the users of original MacClatchie mud valves that come from authorized dealers.

There are more MacClatchie Valves used than any other make. Quality is responsible.

There is one reason why each MacClatchie tool gives better service. This is one of a series telling why.

MacCLATCHIE MANUFACTURING CO.

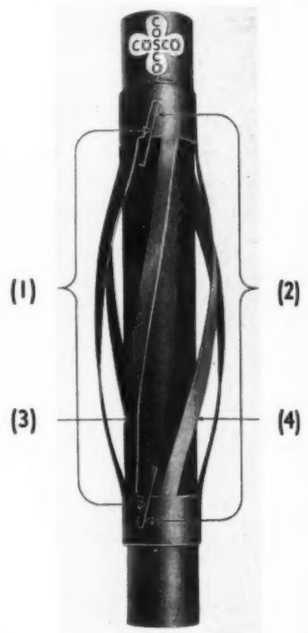
COMPTON, CALIF. • HOUSTON, TEXAS

Export: George R. Woods, 17 Battery Place, New York City

Cosco Well Bore Cleaner

OIL operators agree that cementing off is one of the most important single operations in the successful completion of a well, but a positive water shut-off is often hindered by a thick lining of mud on the well bore, channeling of cement, and leaning casing. What is said to be a solution to these cementing problems is the new Cosco Well Bore Cleaner and Casing Centralizer recently announced by the Coast Oilfields Supply Company.

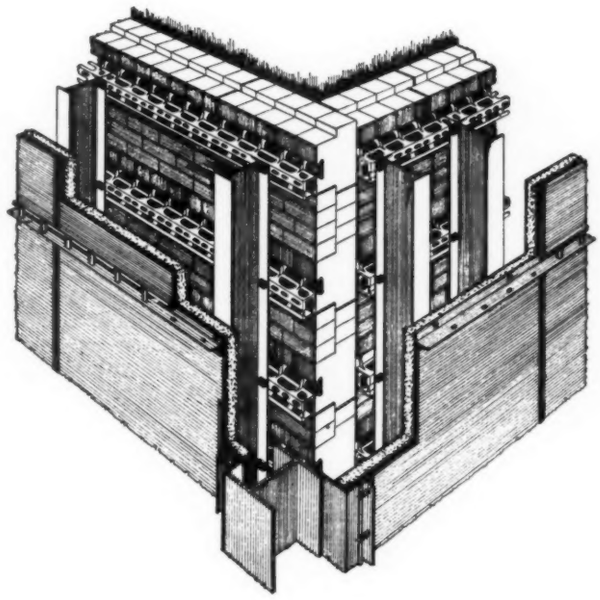
The Cosco Well Bore Cleaner and Casing Centralizer scrapes the lining of mud from the wall of the well so that the cement can unite with the formation. As the drilling fluid passes the cleaner it is whirled around the casing due to the advanced design of the tool. This whirling action helps to eliminate channeling of the cement. Because of the spiral and undertwist of the springs, the casing is held away from the wall of the well so that the cement can be distributed evenly and entirely around the casing. This tool is licensed under two basic patents with five (5) additional claims allowed by the Patent Office.



(1) Shows method of preventing cleaner from rotating by use of lugs on casing.
(2) Shows method of pulling the cleaner downward or upward by use of lugs in slotted collars.
(3) Shows the smoothing edge of the springs. The opposite is the scraping edge.
(4) Shows angular pitch of spring, which acts as a fin to the fluid.

Literature illustrating and describing the Cosco Well Bore Cleaner and Casing Centralizer is available from the manufacturer, Coast Oilfields Supply Company, 822 East 60th Street, Los Angeles, California.

Reintjes Development In Supported Furnace Walls



A DESIGN of supported furnace wall, as illustrated, has been developed by the Geo. P. Reintjes Company, Kansas City, Missouri, with the following principles in mind:

The wall is sectionalized, each section being built totally independent of any other section.

The weight of all the refractories is transferred to a supporting steel frame work.

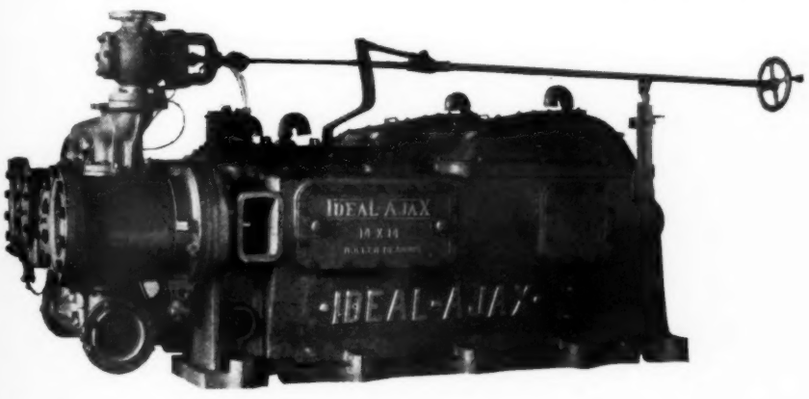
The wall is designed in such manner that all supporting metal is entirely in the back of the refractory, where it can be cooled by circulating air.

The joints are broken so as to prevent infiltration of air into the furnace.

The spacing of the refractory belts can be varied simply by increasing or decreasing the number of courses of standard fire brick.

This flexibility reduces the number of casting and tile shapes required.

Improvements to Ideal-Ajax 14 by 14 Twin Steam Engine

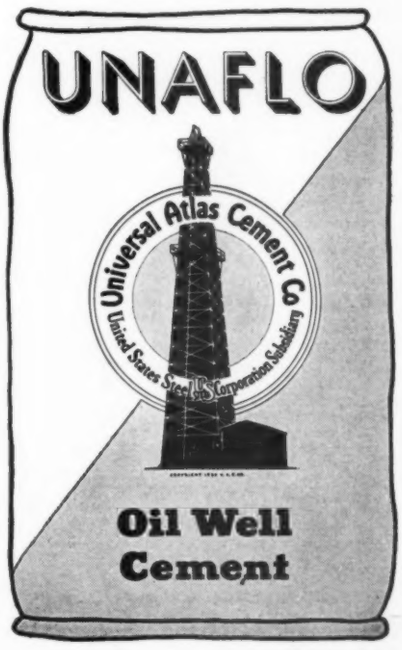


A NUMBER of improvements have been made to the Ideal-Ajax 14 by 14 twin-cylinder roller-bearing steam drilling engine by The National Supply Company, Toledo, Ohio. Among the more important of these are roller bearing crank and connecting rods and automatic cylinder relief or dump valves, both of which are regular equipment on all engines.

The automatic cylinder relief or dump valves, attached to each end of both cylinders, contain a differential piston or valve. This is subjected, on the bottom, to steam chest pressures, and when these are exceeded by the pressure within the cylinders the valve opens, automatically allowing any water inside the cylinder to escape. Safe operation is provided by the new extra heavy automatic steam manifold relief or bleeder valve. This valve remains closed while the engine is operating, but when the throttle valve closes it automatically opens and relieves pressure from the manifold and cylinders. This prevents the engine from turning over due to a leaky throttle valve.

A decided contribution to greater ease of operation is the Ajax reverse lever and throttle control. This enables the operator to control both the reverse lever and throttle valve simultaneously by means of one hand wheel. Sprockets with machine cut teeth also are now available to give greater efficiency and smoothness in operation. They can be supplied both for No. 4 A.P.I. chain and the new 3⅛-in. pitch double roller chain that lately has been introduced. An improved type McCord lubricator that supplies oil in direct proportion to requirements is regular equipment. Each of its three feeds can be adjusted independently.

The Ideal-Ajax 14 by 14 twin engine is a large and powerful drilling engine made to withstand safely a continuous steam working pressure up to 400 lb. per sq. in., the manufacturers state. It is particularly adaptable to deep drilling where long strings of pipe, super-strong equipment, and high steam pressures are necessary, the makers point out.

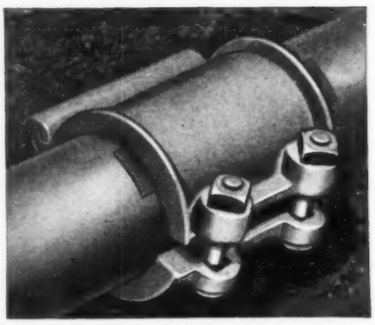


GIVES YOU MORE TIME TO GET IT DOWN. See Page 81

Clamp for Stopping Pipe Leaks

EASILY applied clamps for permanently stopping leaks in pipes, regardless of how large or small, whether high or low pressure, are in valuable use today on pipe lines carrying air, gases, heavy or light liquids, solutions, etc. They are applied while pipe lines are in service except upon extremely high-pressure lines.

The increasing demand for pipe clamps of this type, as well as the higher pressures being adopted in pipe lines today, are responsible for the redesigned pipe clamp illustrated here, a product of the M. B. Skinner Company, 3759 W. Sample Street, South Bend, Indiana.



The new specifications for these clamps require a metal of higher tensile strength, uniform density and hardness. To insure that every clamp is as perfect as humanly possible, this company has installed sufficient new testing equipment to test each clamp under a pressure of 3000 lb. before it leaves the factory.

These clamps are available for stopping leaks in gas, steam, vapor, gasoline, oil, chemical, ammonia, brine, and all other types of pipe lines, high or low pressure.

Permax Hydrometer

THE manufacturers of Permax, a new type hydrometer, claim for their product three outstanding innovations. The most obvious change is in appearance — it's streamlined. Graceful, flowing lines permit it to sink more rapidly to the floating point. There are no indentations to trap air bubbles when used in very viscous liquids, it is stated, and it is easily cleaned.

The most fundamental changes, however, are in the scale, the method of anchoring it, and the permanent accuracy they assure, the makers point out. The scale is enameled, light-weight metal, and is fused into the alloy-weighing material; all of which will stand a temperature of 300 deg. fahr. without discoloring or loosening. This provides a substantial margin of safety for heavy oils that require heating before taking gravity readings. Paper scales char and discolor when exposed to these temperatures, and the adhesive breaks down, loosening the scale, it is stated.

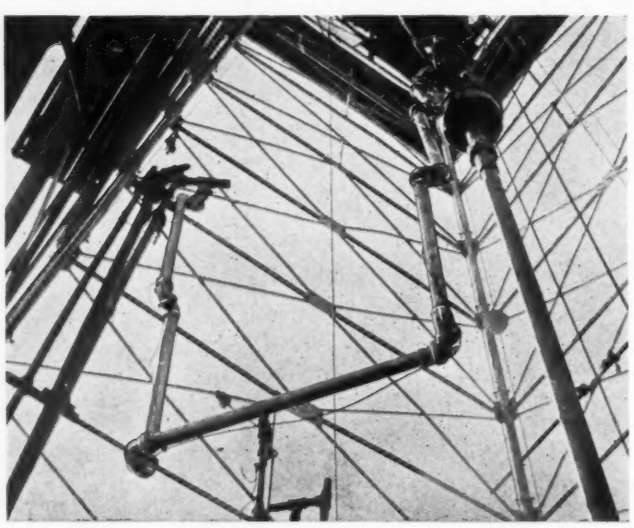
The flat scale with graduations and figures on both sides is said to give at least three times the angle of vision obtainable with the regular paper scale type of instrument, and ease of reading is second in importance only to the permanent accuracy of the hydrometer itself.

This new type hydrometer, known as Permax (PERmanent accuracy, MAXimum visibility) is a patented development of the Taylor Instrument Companies, Rochester, New York.

The Chiksan All Steel Heavy Duty Rotary Hose has a positive safety factor under all drilling conditions. It cannot kink or break down and is unaffected by sudden rises in pressure. Yet it is perfectly flexible and weighs less than conventional types. It is indispensable for "Pressure Drilling" as it is unaffected by oil.

Get a Chiksan All Steel Hose and cut costs by using it for both the mud control method and "Pressure Drilling". It is ordinarily good for 50,000 to 100,000 feet of hole.

Write for new Rotary Hose Folder.



Chiksan

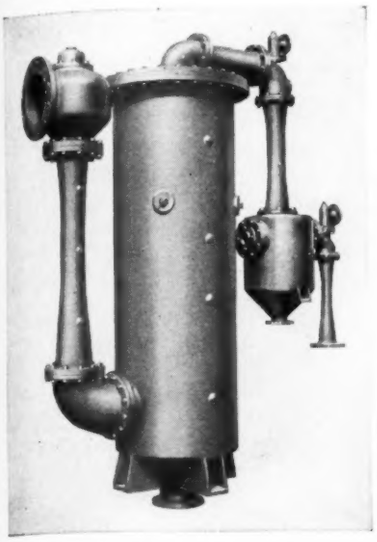
CHIKSAN OIL TOOL CO. LIMITED

FULLERTON, CALIFORNIA — GULF ENGINEERS INC., HOUSTON, TEXAS

PACIFIC NORTHWEST DISTRIBUTOR — E. C. GRIFFIN 401 6th AVE. NORTH SEATTLE WASH.

Worthington Steam-Jet Ejectors

FOR producing vacuums from a few inches of mercury to within less than one millimeter of perfect vacuum, Worthington Pump and Machinery Corporation of Harrison, New Jersey, is offering steam-jet ejectors in single or multiple units. The Worthington ejector, based on fundamental



thermodynamic principles, is the result of thousands of tests over a period of 18 years, the manufacturers state.

In a new illustrated bulletin, W-205-B2, various types of this unit are shown in their application to many industries such as chemical, petroleum, wood-treating, and general processing, together with condensers for power-generating stations. This bulletin contains a chart showing the economical ranges of vacuum and capacity for standard single- and multi-stage units together with a saturated vapor-pressure curve.

Study Behavior of Ball in Cage of Pump

HOW does a ball behave in the cage of a pump at the bottom of a well? Answers to this question have been sought and obtained by studies carried on recently by engineers of the Axelson Manufacturing Company, Los Angeles, California.

In cages with too much clearance between the ball and the ball guides, or wings, it was found that on lifting from the seat the ball would travel over to one side of the cutaway section, follow it to the top, jump over to the center portion of the ball bumper at the top and then roll over to the opposite side and follow that opening down to the seat. Instead of settling directly in the seat, the ball would hit the edge, carom over to the opposite side and finally take its proper place. Constant impacts on the edge of the seat made it out of round at the areas directly under the opening in the ball guides, and when the ball guides were not hardened they were soon beaten out, and in this condition the disturbance was aggravated and the wear accelerated.

In cages that had no ball guides, the ball flopped, spun around and traveled in all directions, resulting in short life and defective operation. In the presence of an excessive volume of gas, the ball spun at a high rate of speed, or seated itself three to five times at each stroke.

Conclusions from these experiments are that the clearance between ball and guides should be reduced, and tests made with new type Axelson cages in which the clearance is only .040 in. to .050 in. proved that the ball travel was straight up and down, with immediate concentric seating. By making the guides of heavy-duty cages extremely hard on the inner surfaces, friction and impact are reduced and longer life results. Incidentally, of course, the efficiency of the pump is notably increased.

HERCULES
OIL WELL SPECIALTIES

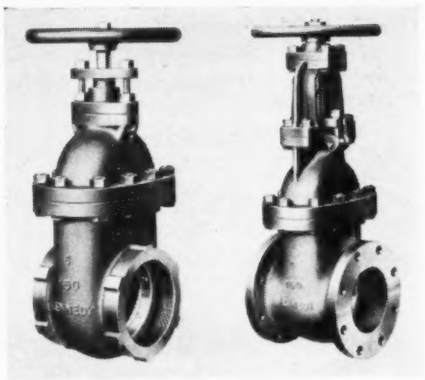
The HERCULES TOOL COMPANY meets the exacting requirements of oil operators with well head connections of advanced design. The HERCULES *"Overhead-Packing"* arrangement is an exclusive feature of our Casing and Tubing Heads, Tubing Hangers and Flow Heads. We show here, a number of HERCULES Specialties that are setting new and higher standards of operating efficiency throughout the oil country.

For full particulars on our complete line, write for the new* HERCULES *Catalog No. 36, or see 1936 Composite Catalog, pp. 629-631.

HERCULES TOOL COMPANY

TULSA, OKLAHOMA. P. O. Box 286. Phone 3-9138
Branch Office: FT. WORTH, Fair Bldg., Box 954. Phone 2-7028
Cable Address: HERTOCO

Kennedy Iron-Wedge Valve



A NEW line of standard iron-body wedge gate valves developed by the Kennedy Valve Manufacturing Company, Elmira, N. Y., has several features of interest.

The metal in these valves is of a particularly dense structure. Further to insure strength and rigidity, the bodies are of oval section with well-rounded corners, the flanges and bolts are heavy, and ribbing is provided at the flanges on the larger flanged-end valves and at the yokes and caps of outside-screw-and-yoke valves.

There are no studs at any part of the valves, and all bolts have the nuts above the flanges and with ample room for standard open-end wrenches. In addition to this feature of convenience, both non-rising stem and outside-screw-and-yoke types have special provisions to facilitate repacking.

An additional feature of interest is the use of heavy bronze bushings wherever the stem passes through a cast-iron part. These bushings prevent corrosion and scoring of the stem that might make operation more difficult and wear out the packing quickly.

The screwed-end valves have round ends for best distribution of metal and lugs for convenient application of pipe or chain wrench. Handwheel rims are of oval section and have only five spokes, permitting ample room for the operator's hands even if gloved.

The discs are reinforced with interior posts, are self-draining in any position and are reversible and interchangeable. Stems have Acme standard threads with thread contact surface at least one and one-half times the stem diameter. Special provisions in both non-rising stem and outside-screw-and-yoke types keep the stem in perfect alignment at all times.

These valves are made in all standard sizes from 1½ in. to 60 in. for steam working pressures of 150 lb. and water working pressures of 200 pounds.

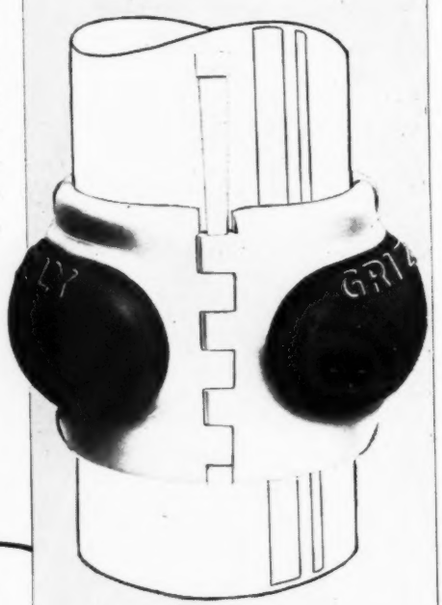
The Improved

GRIZZLY

DRILL PIPE PROTECTOR

Better than ever before

Continuous development and improvement by Grizzly engineers enables Grizzly Drill Pipe Protectors to remain way out in front of the field in efficient protection and long life. Grizzly protectors today are the finest ever produced. Ask your supply man about its improved features and performance.



E. M. SMITH COMPANY

600-650 South Clarence St., Los Angeles, Calif., U. S. A.

Sold in the Mid-Continent and Gulf Coast by: Continental Supply Co., T. T. Word Supply Co., Houston, Texas - In All Their Stores: Independent Pipe & Supply Co., 2311 West St., Houston, Texas

Export Office: Continental Emsco Company, 30 Rockefeller Plaza, New York City.

MAKES SQUEEZE AND PLUG-BACK JOBS EASIER, SURER AND MORE SUCCESSFUL. See Page 81

ANNOUNCING

OIL-WORLD EXPOSITION

OCTOBER 11-16, 1937

In the New
$1,337,000 Exposition Building

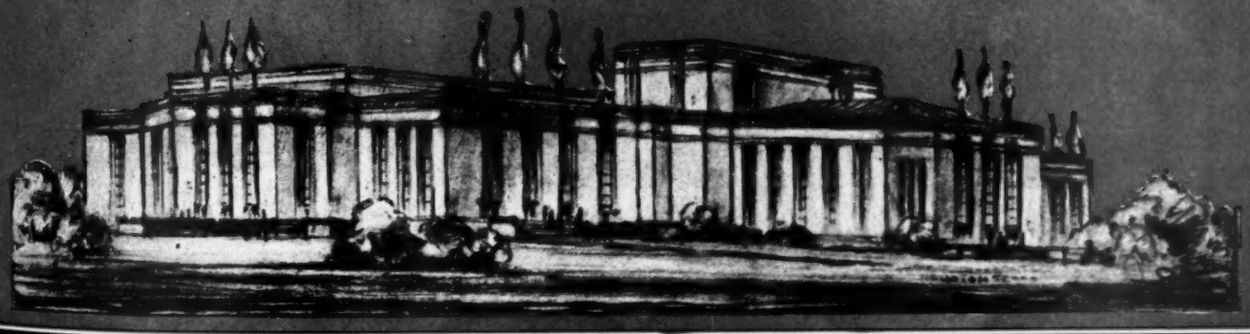
HOUSTON • TEXAS

THE *Only* OIL SHOW IN 1937

- Owned and Directed by the Oil Industry.
- International in scope.
- Operated Strictly on a Non-Profit Basis.
- To be held in Houston every second year.
- To present progress of equipment and methods in All Branches of the Industry.

One SHOW EVERY 2 YEARS

FOR FULL INFORMATION ADDRESS
ED LENZNER, GENERAL MANAGER
OIL-WORLD EXPOSITION, INC.
PETROLEUM BLDG., HOUSTON, TEXAS



Petroleum Bldg. OIL-WORLD EXPOSITION *Houston Texas*

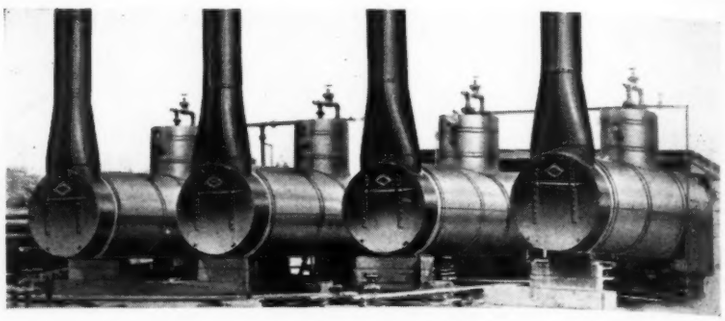
INCORPORATED

OWNED AND OPERATED BY THE OIL INDUSTRY

Boiler Insulation Has Winter Advantages

AN interesting new development in boiler efficiency, of importance to the oil industry with the advent of cold weather, is the steel-jacketed boiler insulation perfected by the Lucey Boiler and Manufacturing Corporation, Chattanooga, Tennessee.

Advantages claimed for this "overcoat for boilers" include a marked saving in fuel and greater boiler efficiency; one-third less pressure drop and steadier steaming, the effects of weather conditions being negligible.



The Lucey Insulation Casing consists of a steel shell of 1/16-in. thickness lined with a 2-in. blanket of Eagle-Picher mineral wool insulation, with ¾-in. air space next to the boiler. The jacket is made in 16 sections easily installed after the boiler is set up, and is held in place by adjustable steel bands, easily removable for boiler inspection or repairs.

COOK'S RINGS *excel*
because they're made of
COOK'S GRAPHITIC IRON

WHAT COOK'S GRAPHITIC IRON IS

A refined cast iron free of all steel-like inclusions and other abrasive matter and permeated with excess carbon in the form of graphite flakes. Its Brinell hardness provides a favorable differential between ring and cylinder.

AVAILABLE ONLY IN COOK'S RINGS

You can get COOK'S GRAPHITIC IRON only in COOK'S Rings, made in all conventional styles and in special designs including COOKTITE Sealing Rings, Oil Control Rings and Sectional Compressor Rings.

ECONOMIES FROM COOK'S RINGS

Comparative operating data show that when COOK'S Rings replace ordinary rings, cylinder wear is retarded, ring replacements and shutdowns for repairs are fewer, and engine life is prolonged.

WHERE COOK'S RINGS EXCEL

Where superior wearing properties are needed to meet conditions of poor lubrication, extreme pressures and high temperatures, COOK'S Rings get the call. They're the accepted standard in the Petroleum Industry for Natural Gas Pumping engines, Gasoline Extraction units and Oil Pipe Line engines. They're working successfully in Steam Engines operating under a total pressure of 1840 pounds at 797° F. total temperature. They predominate in Diesel Trade because they increase cylinder life as much as 50%. In Ammonia Compressors and similar services where lubrication is a problem, COOK'S Rings have repeatedly proved they have longer life.

HOW TO ORDER COOK'S RINGS

Since COOK'S Rings fit existing grooves, the usual information only is required to fill your order. Make sure of getting the genuine by specifying COOK'S Rings on your replacement requisitions or on orders for new engines. Send emergency orders direct to our home office. Write today for the complete story on COOK'S Rings.

C. LEE COOK MANUFACTURING CO.

INCORPORATED

New York Cleveland Baltimore Los Angeles LOUISVILLE, KY. Chicago Tulsa San Francisco New Orleans

Timken Sicromo Steels

TO enable engineers and operators to achieve the economic balance essential to minimum production costs in refinery and other high-temperature operations, The Timken Steel and Tube Company, Canton, Ohio, has developed a new series of steels, to be known as Sicromo 1, 2, 3, and 5.

These new Timken high-temperature steels extend the economic possibilities outlined by Timken DM steel, the first silicon-chrome-molybdenum alloy offered for high temperature use. Sicromo steels contain the 0.5 percent molybdenum that has been found to be most effective for increasing creep strength on an economic basis. Their high silicon content develops the desired degree of oxidation resistance while economic resistance to corrosion is assured by the varying percentages of chromium indicated by the numbers.

Sicromo 1, 2, and 3 are particularly suitable for use in high temperature applications where low to medium oxidation and corrosion resistance is required. Sicromo 5 is designed for use where severe corrosion and oxidation is encountered, yet where equipment cost must be held to the minimum consistent with economic life and efficient operation.

Produced in electric furnaces under the most rigid chemical and metallurgical control, this new series of Timken Sicromo steels offers high grade, dependable alloy steels designed to aid those in the high temperature industries solve their tubing problems most economically.

Changes in Personnel of Cummins Engine Company

Two important executive personnel changes at the Cummins Engine Company, Columbus, Indiana, were announced recently by Paris E. Letsinger, vice-president in charge of sales. Effective November 1st, C. A. Buxton, formerly general service manager of Cummins, was made assistant sales manager. His work will be with Mr. Letsinger. For the past 12 years Buxton has been with the Cummins organization, in the capacity of works manager for a number of years, then later purchasing agent, following which, in 1933, he was made general service manager. His years of experience in both the manufacturing and consumer ends of the business particularly qualify him to act as assistant sales manager.

C. A. BUXTON

DAVE S. CRAVEN

Succeeding Buxton in the position of general service manager is Dave S. Craven, until recently of San Francisco. It is of interest that Craven should have been associated previously with Mr. Letsinger while the latter was district manager for the White Motor Company in San Francisco. Craven was his district service manager. More recently Craven has been in charge of the transportation equipment of the Purity Stores, Ltd. They are one of the larger chain grocer organizations with headquarters in San Francisco and were one of the first users of Cummins Diesel engines on the West Coast.

Mr. Letsinger also has announced the subdivision of the United States into four regions, with four district managers in charge of the respective dealer organizations. In the Eastern region is Deloss C. Cummins with headquarters in New York; in the Southern region is Jerome C. Chambers with headquarters in Fort Worth; in the Central region is A. E. LeBlanc with headquarters in Chicago, and in the Western region is Dave Buttles with headquarters at Fresno.

"The changes in our executive staff, and the appointment of district managers have been occasioned by the tremendous increase in the sale of Cummins Diesel engines for automotive, industrial, and marine service," stated Mr. Letsinger just prior to his leaving for Chicago where he attended the American Truck Owners Convention.

Champion on Extended Trip

Frank Champion, general sales manager for the Oil Tool Division of Byron Jackson Company, is on an extended business trip through the Mid-Continent and Gulf Coast fields, and the East. He plans to return to Los Angeles early in December.

Welding Society Lecture Course

The New York Section of the American Welding Society has arrange with the Brooklyn Polytechnic Institute to present this winter a series of lectures on the fundamentals of welding. The lectures are being given in the Institute, 99 Livingston Street, Brooklyn, on Tuesday evenings at 6:45. They started November 10th.

OTIS PRESSURE CONTROL SERVICE EQUIPMENT

RUNNING TUBING (7216' of 2½") **UNDER PRESSURE** (2200 Pounds)

Several officials of large oil companies witnessed the operation pictured: Running 7216' of 2½" upset tubing against 2200-lb. well pressure in the Moore, Oklahoma, field.

These officials were impressed with the simplicity and safety of this work in the hands of an OTIS crew, working with patented OTIS equipment.

This service is available throughout the Mid-Continent and Eastern fields.

OTIS Removable Bottom Hole Choke

This Choke is used successfully in many fields to:

- .. ELIMINATE FREEZING
- .. REDUCE EMULSIFYING
- .. STEADY AND PROLONG THE FLOWING LIFE
- .. REDUCE GAS/OIL RATIOS.

OTIS PRESSURE CONTROL, Inc.

Tower Petroleum Bldg. . . Dallas, Texas

HOUSTON, TEXAS
MIDLAND, TEXAS
OKLAHOMA CITY, OKLA
HOBBS, N. M.
ADA, OKLA.

Unwatering Pipe Lines After Testing by Hydraulic Pressure

By ELTON STERRETT

WATER is universally used for pressure testing of new lines or rechecking old pipe lines after an extensive reconditioning program. Removal from the line of all the water so used presents a problem as varied as is the profile of the line tested.

If the line tested is destined for handling crude, the presence of more or less residual water in the low spots after most of the liquid has been pushed out ahead of the column of crude is perhaps not such a serious matter, as the water eventually will be picked up by the stream of oil and deposited in the bottoms at the receiving tanks. But if the line has been converted from a crude carrier to one handling gasoline, the spread between specific gravities is such that the water more successfully resists being picked up by the stream of gasoline and, the pressures and consequent fluid velocities being less, there is less intermingling of the two liquids due to turbulent flow.

The presence of water in a gasoline line scarcely can be avoided, due to the need of cleaning such a line with some type of caustic solution that, in turn, must be flushed out with water. With the first gasoline through the line a large part of the water will be carried into the tanks; but inevitably there will remain sizeable slugs of water in the low spots to reduce the effective cross-section of the carrier for a lighter fluid and cause pressure build-up at the pump end far in excess of that required to handle the rated quantity in a clear line of the same nominal diameter.

Where the line may be divided into sections short enough to enable the velocity of the gasoline stream to be stepped up sufficiently, the rapidly-flowing column will pick up and carry with it most of or all the trapped water. But when this velocity can not be attained the flow of gasoline merely moves the slug of water from its resting place in each low-lying sag to some point along the next upgrade to where the system of line pressure, ratio or spread of fluid gravities, fluid velocity, and friction components between water and pipe and gasoline and water surfaces are in equilibrium, only to have the water slip back to its former resting place in the sag when pressure is reduced or pumping stopped.

Tapping the line and installing outlets in each low spot would, of course, enable the water to be drained from the line, but at the same time, would present all too convenient opportunities for line-tapping and consequent gasoline loss. The alternative of running the line with uniform hydraulic gradient from station to station, so that all entrained water might be removed under supervision by station operators, is needlessly expensive. For example, for the type of terrain found in East Texas it would be necessary to follow the windings of some stream and thereby quadruple the mileage of the usual crow-flight pipe line.

One pipe line company, finding that its gasoline line would carry but little more than half its theoretical capacity, attempted to force out the slugs of trapped water, which were rightly blamed for the condition, by sending the usual "Northrup" type of scraper through the line.

After the first run there was no appreciable change in pump pressure or hourly throughput, the only net visible result being a set of scraper leathers cut to ribbons by "welding icicles" and other interior irregularities of the pipe. On a second run, with a theoretical average velocity of stream of three ft. per sec., three scrapers were released at 75-second intervals, in the belief that each would carry a portion of the water slug up the adverse slopes in the line and thus act as magnified links as in the old-fashioned chain-and-washer type of well pump.

Thiefing of the receiving tank after this run showed that the experiment had netted nearly 300 bbl. of water, but again the leathers were cut to shreds and undoubtedly had been effective only at the outset of their trip.

Working from this basis, the leathers were replaced with discs cut from Gandy belting. Two such discs riveted together with their strands at 45 deg. to each other were used to replace each leather. These packers survived the run in much better condition than their predecessors, but brought ahead of them only such small quantity of the total water that computations and careful gauging showed must still be in the line, that the run was not justified.

A special scraper was then rigged-up on the frame of the standard "Northrup" type, by removing the curved scraper arms and putting in their stead eight flat sections resembling those used to back up the leathers. These sections were fitted with ears to be held forward of perpendicular to the axis of the scraper by the springs normally actuating the curved scrapers, and there employed to support a disc of Gandy belting, cupped forward instead of to the rear, as with the pusher leathers.

Further support to this cup was provided by removing the pins serving as pivots for the forward set of centering arms and replacing them with others enough longer to enable the ends of coiled springs to be slipped under the head and cotter pin of each. The rearward ends of these springs were hooked to eye bolts carried through the belting disc and secured with nuts behind each of the eight supporting plates.

The cup so formed was held securely in shape by the two systems of springs, but if jammed against too large a projection for it to ride over, could yield by reversing the cup of the disc and thus be forced ahead through the line. After passing such an obstruction the action of the two systems of springs returns the cup or piston to its former forward cupping.

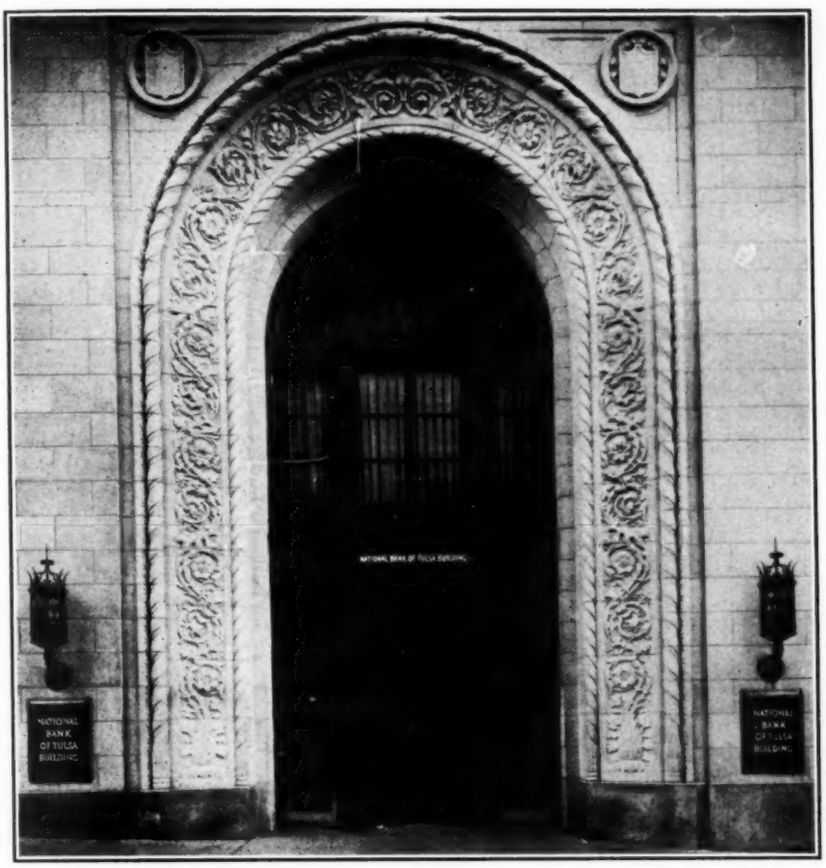
Much was expected of this so-called "piston-displacement" scraper before it was launched on its first run, but when it was taken out after traversing the first leg of the long gasoline line the cup was found to be so twisted and distorted as to be scarcely recognizable. The forward-facing sections appeared to have been hammered severely, the springs relied upon to hold the cup in shape were stretched or broken, and the cup itself ripped with radial tears extending inward an inch or more from its periphery.

After a post mortem on the wreckage it was conjectured — in the absence of definite data — that the speed had been too great for the device. Accordingly it was rebuilt and strengthened where weaknesses had developed, and when next run the throughput in the line was reduced to bring the average velocity of the gasoline stream down from three ft. per second to slightly less than one-third that figure.

The conjecture was proved correct when the slowly moving piston of the scraper picked up slug after slug of water as it reached their resting places, forcing the heavier fluid ahead of itself so effectively that a pressure survey of the line after but one passage of the device proved that approximately 80 percent of the throttling effect had been removed. Proving also

(Continued on Page 156)

A REAL OIL BANK
IN ALL THAT THE NAME IMPLIES



THE policy of the NATIONAL BANK OF TULSA is—"let's go out and look the proposition over", and as a result the officers know how to make sound oil loans that are to the best interest of both parties. Talk over your proposition with men who speak the oil man's language and understand your needs.

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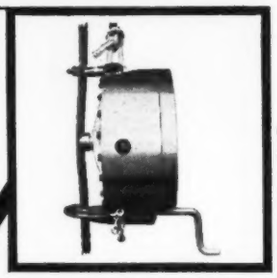
The Oil Bank of America

Member Federal Deposit Insurance Corporation

·THE WEIGHT INDICATOR WITH LABORATORY ACCURACY AND OIL FIELD RUGGEDNESS·



THE FINEST, MOST ACCURATE WEIGHT INDICATOR YET OFFERED THE OIL INDUSTRY

Clipper

A TRIUMPH IN PRECISION AND RUGGEDNESS

ACCURATE WEIGHT READINGS

—Directly in Thousands of Pounds and in Points. Pressure in "The Clipper" indicator is transmitted by a closed fluid column that eliminates errors that might arise from friction and metal fatigue. The full weight on the indicator is read directly in pounds or in points, regardless of the size of the load, from spudding in to pulling tubing.

TWO WEIGHT INDICATORS IN ONE

—Combining Both the Regular and Supersensitive Weight Indicators in One Instrument. Meets the demands of present-day drilling for: wide range . . extreme accuracy . . strength . . sensitivity and flexibility. Especially useful for shallow drilling, all production work, emergency fishing and all kinds of light weight drilling jobs. It sets a new standard for precise measurement.

LIGHT WEIGHT—COMPACT—WATERPROOF

—Weight only 47 lbs. Streamlined. Self-contained. "The Clipper" is the lightest of all weight indicators and the sturdiest. It is compact, self-contained, and is inclosed in a water-tight, streamlined, aluminum case. It has no projections or angles to hang up on tong lines, etc. Weighs only 47 pounds and occupies less than a square foot of space. Easily carried in a car seat. Installation requires only a few seconds.

CONTROLLED SENSITIVITY

All parts are of the finest workmanship and carefully balanced, making the indicator instantly responsive to slightest changes in load. "The Clipper" is truly as sensitive as a ship's compass. Two sensitivity controls, adjustable at will, control the overthrow or wigwagging of indicator hands. This makes for precise reading on the derrick floor during all operations.

NOT AFFECTED BY HEAT OR COLD

Mechanical compensators automatically correct variations in readings formerly caused from temperature changes.

NO REFILLING OR PUMPING UP OF PRESSURE FLUID REQUIRED

An absence of exposed connections prevents tampering. Filling or pumping up the indicator with fluid in the field is eliminated as each instrument is vacuum loaded and sealed at the factory. A simple safety lock on the top hook prevents snapping or jerking the indicator off the dead-line.

THE WEIGHT INDICATOR

MARTIN DECKER CORP.

LONG BEACH CALIFORNIA

San Joaquin Valley
A. F. McQUISTON, Bakersfield, Calif.

Mid-Continent Distributor
REED ROLLER BIT CO., Houston, Texas

Unwatering Pipe Lines

(*Continued from Page* 154)

that the velocity with which the scraper had been forced against the icicles within the pipe had much to do with the destruction of the packing material, the discs on the slowly-driven scraper came through exhibiting but a fraction of the damage formerly sustained.

Although realizing their method of water removal still leaves much to be desired, officials feel they have improved greatly the practical carrying capacity of their line. As justification for this feeling the officials can point to the continued close checking of water content in the gasoline as pumped against that as received, as compared with the gradual dropping of water content in lines not cleaned.

Hercules and Holland Firm in New Lease Agreement

Hercules Motors Corporation, of Canton, Ohio, has announced the completion of a new and broader license agreement with N. V. Kromhout Motoren Fabriek of Amsterdam, Holland. N. V. Kromhout Motoren Fabriek is one of the oldest, largest, and most prominent gasoline and Diesel engine designers and builders in the Netherlands. For the past two years the company has enjoyed the exclusive distribution of Hercules gasoline engines and power units in Holland and the Dutch possessions, as well as the right to build gasoline engines under Hercules designs. Now this company has acquired in addition the exclusive right to manufacture as well as to distribute Hercules Diesel engines in Holland under Hercules patents.

Jan Goeskoop, of N. V. Kromhout Motoren Fabriek, recently spent several days with Hercules officials in Canton, Ohio, during which the exclusive manufacturing and sales arrangements were closed.

The exclusive license for the manufacture as well as the sale of Hercules gasoline and Diesel engines in Holland does not, of course, in any way affect the rights of American manufacturers of powered equipment (and their representatives) who use Hercules engines, either gasoline or Diesel, it is announced.

Opens New Texas Branches

The Portable Rig Company of Houston, Texas, an established Ensign Carburetor Company distributor, has opened new branches at Corpus Christi and Big Spring, Texas. These in addition to branches of the Portable Rig Company already established at Dallas and Longview, Texas, will provide valuable links in Ensign's distribution facilities now maintained throughout oil and gas fields.

Forrow on Trip for Security

E. W. (Al) Forrow, sales manager, is on an extended trip through the Mid-Continent and Gulf Coast oil country for the Security Engineering Company, Los Angeles, California.

In addition to sales work in connection with the well-known Sievers' Reamer, Forrow is checking some of the outstanding results reported on various tests of the new Security slush pump valve now being made in several areas.

Pelican Opens Houston Store

The Pelican Well Tool and Supply Company, Shreveport, Louisiana, has opened a new store at 1802 Maury Street, Houston, Texas

Conley in Charge for Globe at Oklahoma City

M. J. (Bud) CONLEY

M. J. (Bud) Conley has been assigned by Globe Oil Tools Company to take charge of its new sales and service office at 3118 South Robinson Street, Oklahoma City, Oklahoma. Conley will have an able assistant in J. B. (Jack) Stovall who is also qualified to explain the merits of Globe coring equipment, and Globe basket bits, Globe drilling bits, reamers, etc., to Mid-Continent operators.

J. B. (Jack) STOVALL

Hancock Valve Releases Motion Picture

The Hancock Valve Division of the Consolidated Ashcroft Hancock Company, Bridgeport, Connecticut., has released a four reel motion picture.

The first reel shows how the new Hancock Valves are made, including the first movies ever made of the recently-developed Diamond Boring Machine, said to be the first device of its kind ever built to machine the 500 Brinell stainless steel seats and discs used in these valves.

The second reel shows where Hancock valves are used in all industries.

In the last two reels are dramatized a number of new selling ideas that have proved outstandingly successful.

Moves Office

Drilling and Exploration Company, Inc., announces the removal of its office from Kettleman Hills to 621 South Hope Street, Los Angeles. The company also has offices in the Continental Building, Dallas, and at 25 Broadway, New York City.

NEMA Establishes Welding Development Headquarters

Realizing the need for coöperative development of the industrial applications of the electric welding process, the Electric Welding Section of the National Electrical Manufacturers Association has established development headquarters in the Frick Building, Pittsburgh, Pennsylvania. The welding section has initiated a program of coöperative industry development to investigate the electric welding market and determine the possibilities of extending it. In this program especial attention will be given to application engineering, including (1) the preparation of reliable information on cost savings through the use of electric welding, (2) the preparation of material for the use of and coöperation with construction engineers, designers and architects, and (3) the direct promotion of electric welding by missionary work on important new or undeveloped applications. H. S. Card, formerly editor of *The Welding Engineer* and author of "The Welding Industry," has been appointed development director of the N.E.M.A. Electric Welding Section and will be in charge of the Pittsburgh office.

International Acetylene Association Annual Meeting

The International Acetylene Association is holding its 37th annual meeting in St. Louis, Missouri, November 18, 19 and 20. The keynote speaker will be Philip W. Swain, editor of *Power*. Other top-notch executives and engineers occupy prominent places on the program and will discuss topics of current interest.

Many unusual features besides technical sessions will be of particular interest. There will be a welding and cutting forum on Wednesday the 18th at the Soldan High School Auditorium at 8:15 p. m. This program has been developed by selecting those questions that have been most often asked of the association's technical committees, and of the engineering representatives of the association's members. This meeting should prove particularly profitable to welding superintendents, foremen, and welding operators, as well as to proprietors of welding shops and others interested in the application of efficient welding and cutting methods.

An entirely new feature has been planned for Thursday evening, the 19th, in the welding and cutting round table discussions. These discussions will afford an opportunity to discuss important phases of the oxy-acetylene process with outstanding leaders. The subjects to be discussed include the follow: 1. Welding high- and low-alloy steels. 2. Safety in the handling and use of oxy-acetylene equipment. 3. Codes and welding design and construction. 4. Qualification and training of welding operators. 5. Hard-facing. 6. Merchandising welding shop services. 7. Welding and cutting in engineering education. 8. Oxy-acetylene cutting. 9. Non-ferrous metals and their welding characteristics.

The Morehead Medal for the year 1935 has been awarded to Dr. David Schenck Jacobus for his outstanding leadership in the formulation of codes and procedures that have made fusion welding acceptable. The medal will be presented to Dr. Jacobus during the opening session of the convention.

National Tank Distributor for Armco Surface Casing

The National Tank Company, Tulsa, Oklahoma, has been appointed exclusive distributors of Armco surface casing by the American Rolling Mill Company in Oklahoma, Kansas, Texas, Arkansas, Louisiana, and New Mexico. National Tank has branches in each of these states. Pamphlet No. 70 is now available at the Tulsa office, and at all branches.

Cement Firm Changes Name

Effective November 1st, International Cement Corporation, manufacturers of Lone Star, "Incor" and "Starcor" cements, changed its corporate name to Lone Star Cement Corporation.

FOR SAFE DEEP-WELL CEMENTING AT HIGH TEMPERATURES—See Page 81

Grinding Drills for Pipe Line Station Use

« By JOS. L. INGRAM »

IN engine rooms and workshops one often finds drills of various kinds ground and reground to any and all shapes: lop-sided, flat, no clearance at all, and the points often dressed to a degree that causes them to resemble a center punch. Usually such drills gouge, burr, and when they do finally cut through, turn the bottom of the hole wrong side out, then break with the last chip.

The mechanic actually interested in the quality of his work rather than the quantity, usually will purchase for himself a few inexpensive tools and gauges that can be depended upon for accuracy, and that he is reluctant to loan.

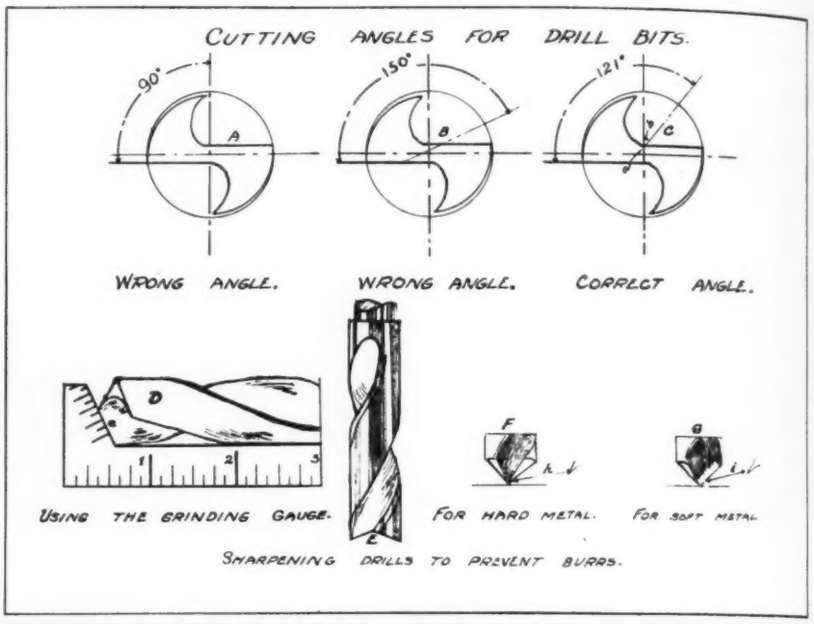
Fig. D shows the use of a drill gauge in grinding and sharpening drills. It is very necessary that the cutting lips be ground to the same angle at the point of the drill in order for it to cut satisfactorily. It can be seen readily that if this angle is not correct the point shown at "b" in Fig. C will have too much slope. Sharpening the bit with the aid of this gauge saves time, also many high-priced drills that otherwise might be broken and discarded.

Figs. F and G illustrate the method used in grinding for drilling in soft metals. When holes of any great depth are to be drilled in copper, lead, etc., the drill often will dig to such a degree that it will either stall or break. In most instances it is possible to obtain a point that will work satisfactorily by grinding away the actual cutting edge of the drill in such a manner that it will have more of a scraping than a cutting action. The degree of grinding necessarily will depend upon the relative hardness of the metal to be drilled, the amount of work to be done, and the thickness of the material. If there happens to be much of this kind of work, it will be well worthwhile to spend a little time to produce a suitable drill.

A point dressed like that shown in E is quite satisfactory for finishing a hole where accuracy is desired and burrs must be eliminated. In using a drill of this kind it is necessary to start with a guide.

Drills, especially where several workmen use them, are about the most abused tools around the shop; however, with a little care in not forcing them beyond their capacity, and in their sharpening and lubrication, it is quite possible to use a drill for many years, thus effecting a very substantial savings in drill expense.

It is suggested that the accompanying chart showing thread sizes and size holes required for drilling and tapping be pasted on a cardboard and hung near the drill rack as a permanent fixture.



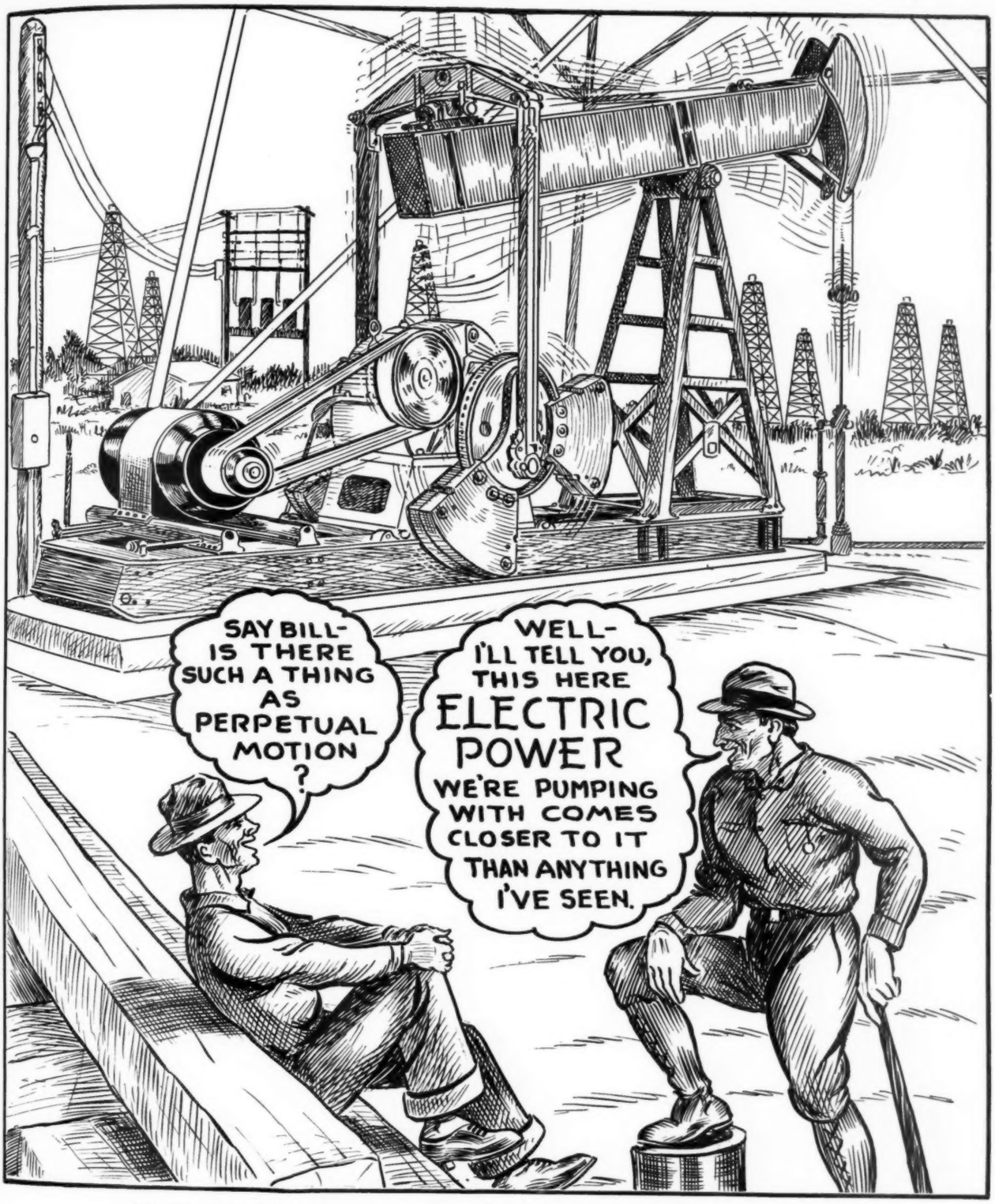
Drill and tap tables for National Coarse Thread Series formerly called U. S. Standard thread. National Fine Thread Series formerly known as S. A. E. Standard.

COARSE THREAD SERIES

Size of Screw	*Threads Per In.*	*Tap Drill Size*	*Decimal Equivalent*
1	64	53	0.0595
2	56	50	0.0700
3	48	47	0.0785
4	40	43	0.0890
5	40	38	0.1015
6	32	36	0.1065
8	32	29	0.1360
10	24	25	0.1495
12	24	16	0.1770
¼	20	7	0.2010
5/16	18	F	0.2570
⅜	16	5/16	0.3125
7/16	14	U	0.3680
½	13	27/64	0.4219

FINE THREAD SERIES

0	80	3/64	0.0469
1	72	53	0.0595
2	64	50	0.0700
3	56	45	0.0820
4	48	42	0.0935
5	44	37	0.1040
6	40	33	0.1130
8	36	29	0.1360
10	32	21	0.1590
12	28	14	0.1820
¼	28	3	0.2130
5/16	24	I	0.2720
⅜	24	Q	0.3320
7/16	20	25/64	0.3906
½	20	29/64	0.4531


SAY BILL- IS THERE SUCH A THING AS PERPETUAL MOTION ?
WELL- I'LL TELL YOU, THIS HERE ELECTRIC POWER WE'RE PUMPING WITH COMES CLOSER TO IT THAN ANYTHING I'VE SEEN.

WHEN YOU WANT TO PUMP 24 HOURS A DAY,
PURCHASED ELECTRIC POWER WILL DO THE JOB.

UNLIMITED
ECONOMICAL
DEPENDABLE

HOUSTON LIGHTING & POWER CO

GENERAL OFFICE—HOUSTON, TEXAS

QUIET
CLEAN
SAFE

ELECTRIC POWER

I.P.A.A. Prepares Interesting Program for Meeting

Announcement has been made by H. B. Fell, executive vice-president of the Independent Petroleum Association of America, that the program and plans for the annual meeting of the association to be held at the Biltmore Hotel in Oklahoma City, Oklahoma, on November 30, and December 1, 1936, practically are completed.

In commenting on the meeting Fell made the following statement: "Although the business sessions cover only two days it is really a three-day meeting, as the first committee meeting will convene at ten o'clock Sunday morning, November 29. Various committees will meet all through Sunday. Eleven committees are being appointed to prepare reports to be submitted to the membership for its consideration."

The Monday morning session, November 30, will include the reports of all officers. That noon a general luncheon will be held in the dining rooms of the Oklahoma City Chamber of Commerce at which one of the outstanding independents in the petroleum industry will deliver an address. During the afternoon session there will be addresses on subjects related to the five-point program of the association and an oil pageant by the Oklahoma City Chamber of Commerce. Following that will be open house and the annual banquet, floor show, and dance. At the banquet there will be addresses of particular interest to oil men by two nationally known speakers.

On Tuesday there will be one address followed by committee reports. After the membership meeting adjourns there will be a meeting of the board of directors to elect officers and a meeting of the executive committee.

The Interstate Oil Compact Commission is meeting in Oklahoma City at the same time.

Fell, who also is chairman of the association's committee on "Balance of Supply With Demand," has announced that, in accordance with the recommendations of the Executive Committee of the association, a subcommittee has been appointed to consider the subject of "unnecessary and excessive drilling in proven fields" and to prepare recommendations and suggestions on this subject for consideration at the annual meeting.

"The personnel of this subcommittee," stated Fell, "is as follows: R. E. Hardwicke, chairman, Hardwicke, Brelsford and Cheek, Fort Worth, Texas; W. P. Z. German, Skelly Oil Company, Tulsa, Oklahoma; Don R. Knowlton, Phillips Petroleum Company, Bartlesville, Oklahoma; C. P. McGaha, Fain-McGaha Oil Corporation, Wichita Falls, Texas; Villard Martin, Tulsa, Oklahoma; J. R. Pemberton, Oil Umpire, Los Angeles, California; A. S. Ritchie, McPherson Drilling Company, Wichita, Kansas; Van S. Welch, Flynn, Welch and Yates, Inc., Artesia, New Mexico; and C. E. Yeager, Texas Pacific Coal and Oil Company, Fort Worth, Texas.

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Byron Jackson Elevator Patents Upheld

Judge Edgar S. Vaught, of the U. S. District Court for the Western District of Oklahoma (Oklahoma City), entered a decree on October 13, 1936, in the patent infringement suit brought by Byron Jackson Company against Arthur F. Spengler and Burney, Warr and Ruble Supply Company of Oklahoma City holding Byron Jackson Company's Well Pipe Elevator Patents Nos. 1,341,577, 1,468,589, 1,486,471, 1,490,445 and 1,498,141 valid and infringed. The judge also granted a perpetual injunction and ordered that all elevators manufactured by the defendants be delivered to the plaintiff, Byron Jackson Company.

Trade Personals

R. H. SONNEBORN has been named assistant manager of sales, Pipe Division, of Republic Steel Corporation, Cleveland, Ohio, according to an announcement by **N. J. CLARKE,** vice-president in charge of sales. Sonneborn formerly was special representative and assumes the position vacated by the appointment late last year of **GEORGE E. CLIFFORD** to the position of district sales manager at Los Angeles, and more recently by **CHARLES W. EAST,** district manager of the Houston district. **MARTIN I. SHEA** will continue as the other assistant manager in the Pipe Division, which position he has held for the past eight years.

R. L. (BUD) MERRILL has been transferred by his company, the Lucey Products Corporation, from Oklahoma City to Shreveport, Louisiana. Merrill has been district manager at Oklahoma City, and assumes the same responsibility in North Louisiana, where the company has a store at Rodessa, and offices at Shreveport. **C. C. WIMBERLEY** takes charge of the Oklahoma City district with headquarters at the company's downtown office. **E. A. LYNCH** has been advanced to store manager.

C. J. FECHHEIMER has joined the engineering staff of The Louis Allis Company, Milwaukee, Wisconsin. For more than 20 years he has been closely associated with the electrical manufacturing industry as a designing and research engineer.

W. W. WILLIAMS, who has been general sales manager for the Babcock and Wilcox Tube Company, Beaver Falls, Pennsylvania, has been made general manager of the company. **T. F. THORNTON,** sales manager of the Detroit district, has been appointed general sales manager.

TEX BRADFORD, who specializes in extinguishing well fires, has moved his office from Corpus Christi, Texas, to Houston. He is associated with **GEORGE BALLEW** and **TED UNRUH,** engineers, and between well fires and capping jobs, will devote his time to general engineering work.

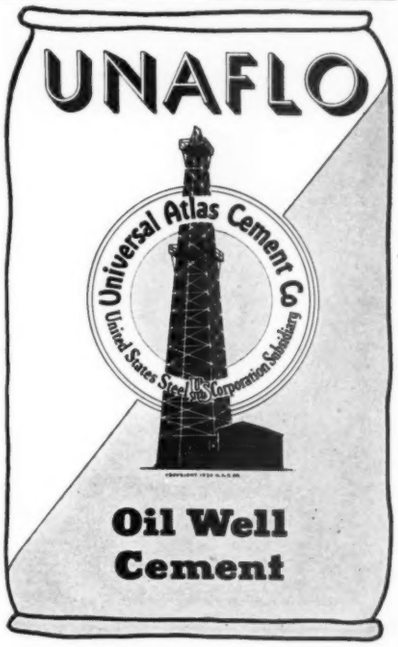
L. L. MACHIA has resigned as Southwestern representative for the Climax Engineering Company to join the Tractor Division of the Allis-Chalmers Manufacturing Company. His headquarters will be at the main office in Milwaukee, Wisconsin, where he is concerned with power unit sales through branches, distributors, and dealers.

DR. L. S. KASSEL has joined the Universal Oil Products Company staff as a research engineer. Dr. Kassel is a graduate of the University of Chicago, was a National Research Fellow of the California Institute of Technology, 1927-1930, instructor in chemistry, University of California, 1930, physical chemist, Bureau of Mines, 1931-1936.

Publish Standards for Pipe Line Valves

The first edition of the American Petroleum Institute's standards for pipe line valves has been published in tentative form by the Division of Production. The edition is known as "A.P.I. Standards, 5-G-1."

This specification was prepared by the Group 1 Subcommittee on Pipe Line Valves of the Special Subcommittee on Standardization of Valves and Fittings, and was approved by letter ballot. Copies are available at 35c each from the Division of Production, 1508 Gulf States Building, Dallas, Texas.



FOLLOWS IRREGULARITIES OF WELL BORE AND CASING—See Page 81

NOW-2 NAILS

for unusual slush pump conditions

Popularity of the SHEAR-RELIEF Valve has spread so rapidly throughout the oil world that demand has arisen for an expansion of the principle to meet special pressure conditions. So, we're now on the market with the 2-nail SHEAR-RELIEF Valve in the 3-inch size for the largest size slush pumps, and where exceptional thru-flow capacity is required. It's a wide-range valve for any hydraulic service and serves two ranges of pressures: Using one nail for the low pressure range, and two nails for the high pressure range.

FLUID-PISTON SLUSH PUMPS
ABERCROMBIE PUMP CO.
GULF BLDG. HOUSTON TEX.

Stay in the Hole . . . .

with your drill pipe and bit
BUT
Keep Your Survey Up
for DIRECTION and INCLINATION
With an
ANDERSON
SMALL PHOTO-RECORD
MAGNETIC SINGLE-SHOT
SURVEY INSTRUMENT

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Used With All Makes of
WIRE LINE
CORING
EQUIPMENT
Send for Bulletin No. 12

The Metal-rimmed Photo-Record Disc is read with an Anderson Reader.

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INC.
FULLERTON, CALIFORNIA, U. S. A.
Surveyors of Oil Wells Since 1924
Directional Drilling

LOOKS LIKE $1,000,000

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And RIDGID 65R Threader Performance is even better than it looks.

RIDGID *No. 65R Threader*

RIDGID designers early decided that a pipe threader might as well LOOK handsome enough to inspire care, even if it didn't NEED special care. So you have this bright, rugged RIDGID No. 65R Threader to take pride in. But at that your chief pride will be in the smooth clean easy job of pipe threading it does. Threads four sizes of pipe with one set of dies, any pipe, any thread variation. New workholder sets to size mechanically and tightens with one screw. Thumb lever releases dies from threads when backing off and reverses ratchet. Straight line action, handle to dies, no cock or wabble. You'll like it. At your supply store.

THE RIDGE TOOL CO., Elyria, Ohio

RIDGID PIPE TOOLS
REG. U. S. PAT. OFF.

Book Reviews

Rotary Drilling Handbook. By J. E. Brantly, president, Drilling and Exploration Company, Inc. Published by Russell Palmer, 716 Bendix Bldg., Los Angeles, California; 56 West 45th Street, New York City; 3, Savoy Place, London, England. 304 pages. Price: Domestic, $3.50, foreign, $4.00.

J. E. Brantly, the author, is a drilling contractor of wide experience, his principal activity having been in Venezuela, Texas, and more recently California. While scientifically trained and inclined he also is a working operator, and in his book has succeeded in approaching rotary rig operation from the practical angle of the man on the derrick floor.

A useful feature of the book is a 70-page section of reference tables and simplified formulas designed to answer regular run-of-the-day problems of rigging up and drilling. The text itself frequently directs attention to the reference material and undertakes to develop a familiarity with it that will result in its use.

The non-technical man could remove many of the disadvantages he works under by adopting the short-cuts open to the engineer, reasons the author, hence there seems to be a useful place in the industry for such a volume.

* * *

The Handbook of Chemistry and Physics. Editor-in-Chief, Chas. D. Hodgman, M.S. Published by Chemical Rubber Publishing Co., Cleveland, Ohio. 2028 pp. Price, $6.00.

The 21st edition of the Handbook of Chemistry and Physics represents a 23-year accumulation of necessary data for the busy scientist and engineer, giving tables, formulas, and scientific facts in a single volume. This latest edition represents an increase of over 175 pages of new composition entailed by complete revision of several important tables.

The mathematical section presents several new features. The numerical table of former editions has been replaced by a new and improved form.

A table of haversines and considerable material on statistics have been added, and the order of arrangement altered so as to place the four- and five-place logarithm tables at the front of the volume.

The collection of laboratory arts and recipes has been completely revised and enlarged by material sent in by a large number of contributors in charge of or associated with educational or commercial laboratories.

The photographic section has been much enlarged and includes a large variety of new formulas and a completely revised table of plate and film speeds given in the Scheiner and in the Weston system.

The increasing availability and widespread utilization of commercial plastics makes particularly appropriate the new and unusually complete collection of data for this class of material.

A revised table of isotopes brings up to date the information in this rapidly changing field.

Increasing convenience in the reduction of gas volume to standard conditions will result from the use of the new special table giving both the factors and their logarithms for such reductions.

Several other small tables have been added and a large number of minor changes and partial revisions have been made.

In addition, the volume contains numerous other features.

Globe Service at Laramie in Charge of Burgess

Charles Burgess has been assigned by Globe Oil Tools Company to take charge of their sales and service office at 158 North Second Street, Laramie, Wyoming.

CHARLES BURGESS

Burgess is a practical oil tool man, well acquainted with the merits of Globe coring equipment, Globe basket bits, reamers, and drilling bits, which, the manufacturers state, are proving to be well adapted to requirements of the Rocky Mountain operators.

Wins Advertising Award

Winning first award in competition with hundreds of advertising exhibits entered by leading industrial concerns, the Merco Nordstrom Valve Company of Pittsburgh and Oakland is receiving congratulations on its entry at the Fourteenth Annual Convention of the National Industrial Advertising Association that convened recently in Philadelphia. The exhibit that took first prize consisted of a series of quadra-color inserts that have appeared in numerous trade journals featuring Nordstrom valves. The campaign was prepared under the direction of Rodney S. Reed, Jr., advertising manager of the valve company, and was placed by The McCarty Company, advertising counsellors.

The Rise of American Oil. By Leonard M. Fanning. Published by Harper and Brothers, New York and London. 221 pages. Price: $2.50.

The book presents, with an interesting historical background, the astonishing role of oil in making our civilization. The geology, the chemistry, and the engineering of the modern utilization of oil are all described in graphic fashion. The numerous applications of petroleum in the creation of power, lighting, heating, air conditioning—in the development of rail, motor, marine, and air transportation, and in the indispensable work of lubrication are set forth in a way that both technician and layman will find entertaining and educational.

Mr. Fanning writes from a thorough familiarity with the history and developments that have accompanied oil's startling rise to power. He was formerly director of statistics and publicity for the American Petroleum Institute and publicity counsel for the Oil Burner Institute. A recognized authority on the background and progress of the petroleum industry, he is the author of numerous articles that have appeared in such magazines as *Fortune*, *Current History*, and *The World Today*. He is now associated with Young and Rubicam.

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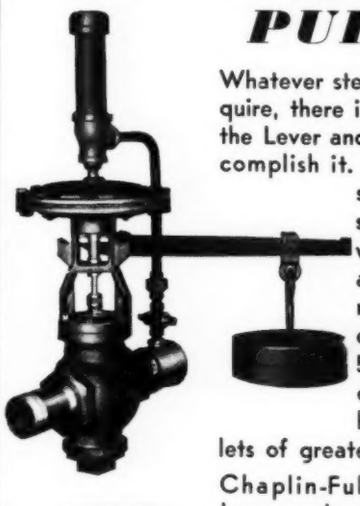

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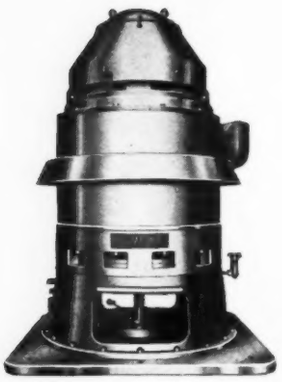

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New Officers, Petroleum Section, National Safety Council

At the twenty-fifth National Safety Congress and Exposition held in Atlantic City, New Jersey, the following officers were elected for the Petroleum Section:

Executive Committee: General Chairman, A. W. Breeland, Lone Star Gas Company, Dallas; Vice-Chairman, A. J. Martinson, Union Oil Company of California, Los Angeles; Engineering Committee: E. D. Murphey, Mid-Continent Petroleum Corporation, Tulsa; Health Committee: Dr. V. C. Baird, Humble Oil and Refining Company, Houston; Poster Committee: H. T. Markee, Phillips Petroleum Company, Bartlesville, Oklahoma; Program Committee: R. B. Roaper, Humble Oil and Refining Company, Houston; Publicity Committee: Glenn Byers, Shell Petroleum Corporation, St. Louis; Statistics Committee: J. W. Myers, Standard Oil Company of New Jersey, New York; News Letter Editor: J. H. Brown, Tide Water Oil Company, New York.

Division Chairmen selected by each group—Atlantic Division: R. L. Simpson, The Texas Company, New York; Great Lakes Division: F. R. McLean, Socony-Vacuum Oil Company, Inc., White Star Division, Detroit, Michigan; Gulf Division: D. B. Hiatt, Texas Pacific Coal and Oil Company, Fort Worth, Texas; Mid-Continent Division: Kraus Earhart, The Texas Company, Tulsa; Pacific Division: L. K. Butler, Union Oil Company of California, Los Angeles; Rocky Mountain Division: B. V. Osborn, Standard Oil Company of Indiana, Casper, Wyoming.

Past General Chairmen: R. W. Black, Standard Oil Company of New Jersey, Elizabeth, New Jersey; R. S. Bonsib, Standard Oil Company of New Jersey, New York; V. R. Currie, The Texas Company, Houston; R. E. Donovan, Standard Oil Company of California, San Francisco; C. L. Hightower, United Gas System, Houston, Texas; G. O. Lockwood, The Empire Companies, Bartlesville, Oklahoma; Geo. F. Prussing, Union Oil Company of California, Los Angeles; R. B. Roaper, Humble Oil and Refining Company, Houston; E. J. Senne, Socony-Vacuum Oil Company, Inc., New York; C. W. Smith, Standard Oil Company of Indiana, Chicago; D. J. Wallace, Sinclair Prairie Oil Company, Tulsa.

Secretary: H. N. Blakeslee, American Petroleum Institute, New York.

Publish New Roster of Standardization Committees

A revised printed roster of the membership of the American Petroleum Institute's Committee on the Standardization of Oil Country Tubular Goods has been published by the Division of Production to replace the June, 1934, edition. The roster includes complete membership of the sub-committee on standardization of valves and fittings, group 1 subcommittee on pipe line valves, and group 2 subcommittee on production valves.

C. A. Dunlop, Humble Oil and Refining Company, Houston, Texas, has replaced W. C. Thomas as chairman of the Southwestern District Subcommittee. H. H. Wright, Gulf Oil Corporation, Tulsa, is chairman of the Mid-Continent District Subcommittee, succeeding C. D. Watson. C. W. Froome, Union Oil Company of California, Santa Fe Springs, California, is chairman of the engineering subcommittee 5A, succeeding J. R. Gignoux. J. Jay Dunn, National Tube Company, Pittsburgh, is chairman of the pipe manufacturers' subcommittee, succeeding T. D. Davies.

Opens San Antonio Office

The Dow Chemical Company, Midland, Michigan, has opened a branch at San Antonio, Texas, in the Alamo National Bank Building. C. T. Young is in charge.

Left—Dale Dublin, assistant manager, Shelby, Montana; Right—C. T. Young, manager, San Antonio, Texas, office.

Fall From Horse Leads to Death of H. M. Myracle

Injuries caused by a fall from a horse led to the recent death of Hobart M. Myracle, secretary-treasurer of the American Iron and Machine Works Company, Oklahoma City, Oklahoma.

H. M. MYRACLE

Myracle's arm was broken near the shoulder when he plunged from the horse when it stopped suddenly while he was riding near the cabin of Judge Orel Busby. While his arm was being set his heart gave way under the strain. Myracle had served as secretary-treasurer of the American Iron and Machine Works Company since its organization in Tonkawa, Oklahoma, in 1923, having moved to Oklahoma City in 1926.

Myracle was born October 25, 1896, at Beacon, Tennessee. He is survived by his father, J. W. Myracle, Selma, Mississippi; his widow, Velma M. Myracle; a daughter, Mary Theresa Myracle; a son, Jack H. Myracle; and four sisters: Mrs. Hugh Owens, Jackson, Tennessee; Mrs. Floyd Muehlberger, Chicago, Illinois; Mrs. Allen Fail, Jackson; Mrs. Tyree Blackburn, Jackson.

Funeral services were held in Oklahoma City.

Statement of the Ownership, Management, Etc., of THE PETROLEUM ENGINEER October 1, 1936

(This statement is published in compliance with the Act of August 24, 1912.)

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General Manager: Clarence Morris, Dallas, Texas.
Editor: K. C. Sclater, Dallas, Texas.
Stockholders holding 1 per cent or more of total amount of stock: C. R. Barrett, W. T. Bryan, W. L. Love, Clarence Morris, K. C. Sclater, Dallas, Texas; J. L. Dwyer and Mrs. J. H. Dameron, of Tulsa, Oklahoma; Warren L. Baker, Houston, Texas; T. J. Crowley and F. R. Staley, New York, N. Y.

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W. T. BRYAN, Secretary-Treasurer.

Sworn to and subscribed before me this 1st day of October, 1936.

S. HIGHTOWER, Notary Public.
(My commission expires June, 1937.)

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TRADE LITERATURE

THE BROWN INSTRUMENT COMPANY, Wayne and Roberts Avenues, Philadelphia, Pennsylvania, has published a new catalog on Brown Air Operated Controllers for the control of temperatures, pressure, flow, and liquid level. The catalog is numbered 8901.

The company also has issued a new catalog on Brown Thermometers and Pressure Gauges, No. 6703.

Either or both of these publications will be sent free upon request.

* * *

A BULLETIN has been issued describing Buda Diesel power for generator sets. The publication is being sent free upon request by The Buda Company, Harvey, Illinois.

* * *

TWO BROCHURES have been issued by The Barrett Company, 40 Rector Street, New York City. One, entitled "Pipe Coating Specifications for Field Application," describes and illustrates in great detail the application of Barrett pipe line coatings in the field. In its booklet entitled "Ammonia in Petroleum Refining," information given is based on current practice in oil refineries throughout the United States and Canada as observed through personal contact with refinery operations.

* * *

THE FULTON House Regulator with automatic cut-off for natural gas is illustrated and described in a pamphlet recently issued by the Chaplin-Fulton Manufacturing Company, 28-40 Penn Avenue, Pittsburgh, Pennsylvania.

* * *

BULLETIN NO. 163, issued by the Oilwell Supply Company, Dallas, Texas, is descriptive of "Oilwell" No. 200 Crown Block, companion to "Oilwell" 66″ Streamline Traveling Block. Operating and construction features, directions for erecting, specifications, etc., are given in the publication.

* * *

A NEW SERIES of booklets on Enduro Stainless Steel has been released by Republic Steel Corporation, Cleveland, Ohio. The booklets, five in number, are characterized by layout and typographical treatment radically different from Republic's previous publications on this product. All of the booklets are profusely illustrated.

First in the series is a booklet of general nature, explaining the reasons for the amazing rise in popularity of stainless steel and illustrating many of the more important applications of Enduro.

A second book features detailed data on Enduro 18-8 and its several variations. The third booklet is devoted to the straight-chromium types of Enduro—AA, S, S-1, and FC. The fourth booklet contains information on the heat-resisting types of Enduro—HCN, HC, and NC-3. The fifth booklet treats Enduro 4-6 percent chromium steels. These latter

Fred Key

Although the name of Fred Key, president of the Key Boiler Equipment Company, East St. Louis, Illinois, is seldom seen in public print, the marks of his inventive mind can be found on oil refinery equipment throughout the world. More than 50 of his patents pertaining to this industry are on file in the United States Patent Office.

FRED KEY

Key was born in Auburn, Kentucky, January 19, 1869, and left there at the age of 16 to make his own way in the world. His education, insofar as that obtained by attendance at public school was concerned, of necessity was limited, Key being what is generally known as a "self-educated" man. This lack of a planned education apparently never handicapped him, however, since he is fortunately equipped to assimilate new ideas in unlimited quantity.

During the years immediately following his departure from Auburn, Key worked at various railroad jobs, eventually settling in Louisville, Kentucky, where he was employed on construction and steam plant engineering jobs.

In 1915 he became associated with Robert L. Dutton and the Key Boiler Equipment Company was formed for the primary purpose of exploiting the Key safety hand hole cap, designed by Key for water tube boilers. This association has continued to the present.

---

steels are not stainless but are intermediate between ordinary carbon and stainless steels.

* * *

"COOPER-BESSEMER Type EN Gas Engines" is the title of a new bulletin issued by The Cooper-Bessemer Corporation, of Mount Vernon, Ohio.

The Type EN is rated 30 to 38 hp. per cylinder and is built in 3, 4, 6, and 8 cylinders. It is one of the popular "N-Line" series. Chief features are conversion to Diesel operation; compact design; inexpensive installation; and reduced costs of operation and maintenance. Free copies of the bulletin will be supplied by any of the Cooper-Bessemer offices, upon request.

* * *

THE UNITED STATES RUBBER PRODUCTS, INC., New York, has issued a practical manual that will serve as a ready reference for engineers, plant operators, and executives on the application of rubber mountings to modern industrial use. The issuance of this manual is to assist engineers in properly adapting the various "U. S." designs to their specific needs. It gives complete engineering data indicating the various characteristics of rubber, graphs showing its deflection curves, and its safety load limits. Descriptive illustrations show specific uses to which these mountings have been put.

* * *

CHIKSAN OIL TOOL COMPANY, LTD., Fullerton, California, has issued a folder describing their line of disc bits, reamers, hole enlargers, all-steel rotary hose, and all-steel cement joints. This bulletin gives full information on sizes and prices. Copies are being sent free upon request.

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